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INFLUENCE OF CHANGE OF STORAGE TEMPERATURE, REFREEZING AND RETHAWING, AND DEFROSTING PROCESS UPON DRIP FROM FROZEN WHALEMEAT

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Introduction

It is a well-known fact that frozen whalemeat yields a large amount of drip on thawing. The authors carried out experiments on influences of change of storage temperature, refreezing and rethawing, and defrosting processes upon the amount of drip from the frozen whalemeat and its quality.

Experimental

1. Feature of Frozen Whalemeat.

It was already reported that three types of whalemeat, i.e. contractile, semi-contractile and non-contractile, can be observed as its frozen tissue is thawed. The contractile type frozen in pre-rigor stage gives a lot of drip showing obviously a feature of thaw-rigor with noticeable contraction of its tissues, the semi-contractile type frozen in full-rigor stage exudes not so much amount of drip showing to some extent the feature of thaw-rigor with slight contraction of its tissues, the non-contractile type frozen in post-rigor stage drips a small amount of the body fluids with no appreciable contraction, on thawing.

Therefore, the experiments were carried out on blocks of lean meat of fin whales caught in the Antarctic waters both in pre-rigor stage and post-rigor stage. The raw meats were cut to a rectangular shape of about $0.12 \times 0.30 \times 0.39$ m in size and roughly 15 kg in weight, and frozen in a multiplate type freezer by $CaCl_2$ brine of temperature $-26°C$ for 8 hours or so. Then, the frozen meats were glazed and packed in cartons.

2. Influence of Change of Storage Temperature upon Drip from Frozen Whalemeat.

Packed frozen whealemeat of both contractile (pre-rigor) and non-contractile (post-rigor) types were stored in cold room at $-8°C$ of air temperature for three months, then, the frozen meats were transferred to cold rooms at $-16°C$ and $-24°C$ of air temperature and kept there for one month. On the other hand, packed frozen whalemeat of both contractile (pre-rigor) and non-contractile (post-rigor) types were stored in cold rooms at $-16°C$ and $-24°C$ of air temperature for three months, then, the frozen meats were transferred to cold room at $-8°C$ of air temperature and kept there for one month. At the

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Table 1. Influence of change of storage temperature (from high storage temperature to low storage temperature) upon drip.

Storage temp. °C	Storage period m	Weight loss %		Thickness contraction %						Drip %						pH				Δ7P-P content in free drip of contractile type mg %	protein N / total N ×100%			
				in 6 hrs.		in 24 hrs.		in 2 5kg/cm²g.[3]		in 6 hrs.		in 24 hrs.		in 2.5kg/cm²g.		in free drip		in exp. drip			in free drip		in exp. drip	
		C[1]	N[2]	C	N	C	N	C	N	C	N	C	N	C	N	C	N	C	N		C	N	C	N
−8	2	0.22	0.41	40.9	14.3	46.0	14.9	34.0	63.8	30.6	12.1	33.7	14.4	11.8	18.6	5.99	5.86	5.91	6.13	27.8	64.9	—	—	—
−8	3	0.65	0.81	48.8	15.0	53.5	20.3	29.0	61.5	33.2	14.0	36.8	18.4	13.0	18.2	5.99	5.79	5.89	6.16	26.9	58.6	56.6	—	—
↓ −16	4	0.65	0.81	43.2	16.1	49.4	18.7	31.7	59.8	31.8	8.7	34.4	10.8	12.0	20.6	5.97	5.89	5.60	5.87	25.1	—	—	—	—

Storage temp. °C	Storage period m	Weight loss %		Thickness contraction %						Drip %						pH				Δ7P-P content in free drip of contractile type mg %	protein N / total N ×100%			
				in 6 hrs.		in 24 hrs.		in 2.5 kg/cm²g.		in 6 hrs.		in 24 hrs.		in 2.5 kg/cm²g.		in free drip		in exp. drip			in free drip		in exp. drip	
		C	N	C	N	C	N	C	N	C	N	C	N	C	N	C	N	C	N		C	N	C	N
−8	2	0.22	0.41	40.9	14.3	46.0	14.9	34.0	63.8	30.6	12.1	33.7	14.4	11.8	18.6	5.99	5.86	5.91	6.13	27.8	64.9	—	—	—
−8	3	0.65	0.81	48.8	15.0	53.5	20.3	29.0	61.5	33.2	14.0	36.8	18.4	13.0	18.2	5.99	5.79	5.89	6.16	26.9	58.6	56.6	—	—
↓ −24	4	0.65	0.81	43.4	17.9	51.3	18.4	33.1	63.2	33.2	6.0	35.7	9.9	11.3	18.7	5.95	5.83	5.63	5.77	26.5	—	—	—	—

C[1]—Contarctile type: The samples of this type are frozen at the pre-rigor stage (pH value in fresh state 7.10) and show contraction on thawing.

N[2]—Non-contractile type: The samples of this type are frozen at the post-rigor stage (pH value in fresh state 5.70) and show no contraction on thawing.

2.5kg/cm²g.[3]—Sqeezing pressure: The expressible drip was exuded under pressure of 2.5 kg/cm²g. after 24 hours exudation of free drip.

Table 2. Influence of change of storage temperature (from low storage temperature to high storage temperature) upon drip.

Storage temp. °C	Storage period m	Weight loss %		Thickness contraction %						Drip %						pH				4P–P content in free drip of contractile type mg %	protein N / total N ×100%			
				in 6 hrs.		in 24 hrs.		in 2.5 kg/cm²g.[3]		in 6 hrs.		in 24 hrs.		in 2.5 kg/cm²g.		in free drip		in exp. drip			in free drip		in exp. drip	
		C[1]	N[2]	C	N	C	N	C	N	C	N	C	N	C	N	C	N	C	N		C	N	C	N
−16	2	0.10	0.21	41.5	5.7	47.3	8.8	34.5	72.3	31.5	3.7	34.4	6.4	15.0	23.4	6.23	5.84	5.92	6.08	30.0	67.8	59.4	64.3	55.9
−16	3	0.10	0.31	45.2	11.1	47.3	16.1	34.5	65.4	33.2	10.1	36.4	14.3	16.4	22.0	6.09	5.77	5.99	6.19	26.6	67.4	57.8	64.7	50.0
↓ − 8	4	0.20	0.42	43.4	12.2	45.1	12.3	30.2	60.1	33.2	6.0	36.7	11.7	13.0	20.4	5.99	5.78	5.58	5.79	26.6	60.7	56.6	62.2	56.0

Storage temp. °C	Storage period m	Weight loss %		Thickness contraction %						Drip %						pH				4P–P content in free drip of contractile type mg %	protein N / total N ×100%			
				in 6 hrs.		in 24 hrs.		in 2.5 kg/cm²g.		in 6 hrs.		in 24 hrs.		in 2.5 kg/cm²g.		in free drip		in exp. drip			in free drip		in exp. drip	
		C	N	C	N	C	N	C	N	C	N	C	N	C	N	C	N	C	N		C	N	C	N
−24	2	0.00	0.00	44.5	8.2	47.7	12.6	33.4	71.0	34.8	6.3	36.9	8.9	12.0	21.8	6.13	5.81	5.70	5.97	38.0	65.3	—	—	—
−24	3	0.10	0.00	47.3	5.8	55.5	18.8	26.3	62.0	36.2	4.9	38.8	10.3	13.0	26.4	6.12	5.85	5.72	5.99	29.4	64.5	56.3	—	—
↓ − 8	4	0.30	0.21	43.4	9.3	48.2	15.0	35.2	59.3	30.6	1.8	33.7	3.0	11.8	18.9	5.99	5.82	5.52	5.76	25.9	61.4	66.2	62.1	56.2

C[1]—Contractile type: The samples of this type are frozen at the pre-rigor stage (pH value in fresh state 6.45 at −16°C, 6.26 at −24°C) and show contraction on thawing.

N[2]—Non-contractile type: The samples of this type are frozen at the post-rigor stage (pH value in fresh state 5.70 at −16°C, 5.70 at −24°C) and show no contraction on thawing.

2.5kg/cm²g.[3]—Squeezing pressure: The expressible drip was exuded under pressure of 2.5 kg/cm²g. after 24 hours exudation of free drip.

end of each definite period of storage, loss of weight of the blocks due to moisture evaporation was measured, and then, the test pieces, having a rectangular shape of about $0.05 \times 0.10 \times 0.15$ m in size of roughly 0.75 kg in weight, were cut from them, and thawed in still air at +20°C. During thawing, values of thickness contraction, drip, pH and protein N/total N in drip were measured on each test piece. With test pieces of contractile (pre-rigor) type, ATP level (shown by Δ7p−p mg/100 cc drip) was also measured. It is presumed that the drip is exuded on thawing from the frozen whalemeat due to the contraction of muscle tissues as well as the liberation of water from the muscle protein due to the degeneration of protein during cold storage and defrosting. Hereupon, we pursued the change in values of both thickness contraction and drip in relation to the APT level and the value of protein N/total N of the drip, taking the former as the index for the contractibility and the latter for the degeneration of protein. The results are given in Table 1 and Table 2.

From the Table 1, in spite of remarkable differences observed between the meats of contractile and non-contractile types, marked differences are not found between the meats kept at −8°C (high storage temperature) and transferred to the rooms at −16°C and −24°C (low storage temperature) and kept there. On the contrary, from the Table 2, the drip values from the frozen whalemeat of both contractile and non-contractile types kept at −8°C (high storage temperature) after having stored at −16°C or −24°C (low storage temperature) are somewhat less than that of previously. This change is more marked in the frozen whalemeat of contractile type than in non-contractile type. Taking into consideration of the changes of pH value and ATP level, it is presumed that the frozen meat of contractile type was gradually turned to semi-contractile (full-rigor) type during post storing. Further, this change is prominent in the frozen meats occurred at the change of storage temperature than that not subjected to change. These experimental results lead us to the conclusion that to reduce drip value, frozen whalemeat of contractile type would rather be kept at comparatively high storage temperature for months after being stored at ordinary low storage temperature before defrosting. But in considering the weight loss of frozen meat due to moisture evaporation, it is clear that the change of storage temperature may not give so good effect to the quality of the frozen whalemeat of both contractile and non-contractile types. So these treatments may not be done.

3. Influence of Refreezing and Rethawing upon Drip from Frozen Whalemeat.

Packed frozen whalemeat of both contractile (pre-rigor) and non-contractile (post-rigor) types were stored in cold room at −20°C or so for about three months, then the frozen meats were kept in room at 0°C for 24 hours and partially thawed, then stored in room at −20°C for 72 hours and refrozen. After refreezing, the test pieces as above were cut from them and thawed in still air at +20°C for measuring each value. The results are given in Table 3.

The drip value from the frozen whalemeat of both contractile (pre-rigor) and non-contractile (post-rigor) types refrozen and rethawed are to some extent less than that from the ordinary not refrozen and not rethawed frozen whalemeat. Further, in the former (pre-rigor) its taste was somewhat increased, but in

Table 3. Influence of refreezing and rethawing upon drip.

Type of meat	Thickness contraction %			Drip %			pH		Δ7p-p content mg %	protein N / total N ×100%	
	in 6 hrs.	in 24 hrs.	in [3] 2.5 kg /cm²g.	in 6 hrs.	in 24 hrs.	in 2.5 kg /cm²g.	in free drip	in exp. drip		in free drip	in exp. drip
Contractile[1]	11.1	14.3	—	8.8	10.3	—	5.82	—	—	—	—
Non-contractile[2]	10.9	15.9	—	5.4	10.8	—	5.77	—	—	—	—

1)—Contractile type: The samples of this type are frozen at the pre-rigor stage (pH value in fresh state 6.65) and show contraction on thawing.

2)—Non-contractile type: The samples of this type are frozen at the post-rigor stage (pH value in fresh state 5.70) and show no contraction on thawing.

3)—Squeezing pressure: The expressible drip was exuded under pressure of 2.5 kg/cm²g. after 24 hours exudation of free drip.

Table 4. Influence of air velocity in moving air defrosting upon drip (at +20°C of air temperature).*

Air velocity m/sec	Defrosting time h	Body temperature of meat °C						Thickness contraction %		Drip %	
		contractile type			non-contractile type			contractile type	non-contractile type	contractile type	non-contractile type
		surface	intermediate	center	surface	intermediate	center				
0	0	+2.0	−4.7	−5.2	+3.0	−5.1	−6.2	0.0	0.0	0.0	0.0
	1	+3.0	−2.5	−3.5	+5.2	−3.0	−4.5	7.4	2.2	3.5	1.7
	2	+7.0	−0.5	−2.0	+8.2	−1.0	−2.5	12.1	5.1	7.4	3.1
	3	+10.2	+2.0	−1.5	+10.3	+2.0	−1.5	16.4	9.2	11.1	5.9
	4	+13.2	+9.5	−0.5	+13.6	+10.2	0.0	31.2	11.3	20.5	7.4
	5	+16.0	+11.5	+1.0	+14.0	+11.0	+2.0	36.6	16.2	25.5	11.2
	6	+16.0	+14.0	+12.0	+14.0	+14.0	+10.8	41.4	21.0	27.9	12.0
1	0	+4.0	−3.2	−4.0	+6.0	−4.0	−4.5	0.0	0.0	0.0	0.0
	1	+16.5	−0.5	−2.5	+8.0	−2.0	−2.5	11.3	4.2	9.3	2.7
	2	+11.0	+12.0	+3.3	+12.0	−0.5	−0.5	34.2	13.5	20.8	7.0
	3	+18.5	+18.0	+17.0	+16.0	+13.0	+5.0	39.2	17.4	25.2	11.9
2.5	0	+8.0	−3.5	−4.3	+8.0	−5.0	−4.5	0.0	0.0	0.0	0.0
	1	+10.5	+2.6	−2.5	+9.0	−2.9	−2.9	15.3	4.1	8.7	1.6
	2	+10.0	+11.0	+4.5	+13.5	+0.5	−0.8	29.4	8.2	17.9	4.1
	3	+18.5	+18.0	+18.0	+14.5	+12.0	+10.0	33.1	9.5	22.6	6.4
4	0	+5.0	−3.2	−4.4	+4.0	−3.7	−4.5	0.0	0.0	0.0	0.0
	1	+14.0	+0.5	−2.5	+6.5	−2.0	−3.0	13.6	2.9	7.5	1.8
	2	+18.0	+10.5	+3.5	+11.0	+0.5	−2.0	27.2	9.4	15.2	4.5
	3	+18.5	+17.0	+17.0	+17.5	+16.5	+16.0	34.5	12.5	19.2	7.8

* The pH value of the sample of contractile type in unfrozen state is 6.65 and that of non-contractile type in unfrozen state is 5.70, in both descending side.

the latter (post-rigor) its taste was much decreased because of disrupture of its tissue by refreezing and rethawing. It is presumed that the former was gradually turned to semi-contractile (full-rigor) or non-contractile (post-rigor) type during refreezing and rethawing process while the latter was not. This fact in contractile type may be considered as a kind of aging of meat at the partially frozen state. But in any case, it is clear that the refreezing and rethawing may not give so good effect to the quality of the frozen whalemeat of both contractile and non-contractile types. So these treatments may not be done also.

4. Influence of Defrosting Process upon Drip from Frozen Whalemeat.

In previous report, the authors described the effect of air temperature in still air defrosting upon drip from the frozen whalemeat. Thereupon, the influences of the other defrosting processes upon drip from the frozen whalemeat will be described.

Packed frozen whalemeat of both contractile (pre-rigor) and non-contractile (post-rigor) types were stored in cold room at −20°C or so for about three

Table 5. Influence of water temperature in still water defrosting upon drip.*

Water temp. °C	Defrosting time h	Body temperature of meat °C						Thickness contraction %		Weight loss %	
		contractile type			non-contractile type			contractile type	non-contractile type	contractile type	non-contractile type
		surface	intermediate	center	surface	intermediate	center				
+5	0	—	−4.4	−5.1	—	−3.3	−4.7	0.0	0.0	0.0	0.0
	1	—	−1.0	−2.5	—	−1.0	−3.0	0.0	0.0	0.0	0.0
	2	—	0.0	−1.0	—	+0.5	−1.0	4.1	2.2	2.3	1.1
	3	—	+1.0	−1.0	—	+2.2	−0.5	8.5	8.1	5.7	4.9
	4	—	+3.0	0.0	—	+2.5	+0.5	15.6	13.1	9.6	7.4
	5	—	+3.5	+0.8	—	+4.0	+1.5	20.7	19.7	13.3	11.2
	6	—	+3.5	+1.5	—	+4.5	+3.0	20.7	19.7	15.4	12.8
	24	—	+4.5	+4.5	—	+4.0	+4.0	−3.4	−2.8	−8.9	−9.7
+10	0	—	−3.5	−4.5	—	−2.5	−2.5	0.0	0.0	0.0	0.0
	1	—	+1.0	−1.0	—	+0.5	−0.5	7.4	9.5	5.3	6.7
	2	—	+5.0	+1.0	—	+4.5	+1.5	13.2	13.9	10.5	11.2
	3	—	+7.4	+4.2	—	+7.5	+6.4	18.6	17.2	14.8	13.8
	4	—	+8.2	+8.2	—	+8.5	+8.5	21.3	21.3	15.6	15.9
	24	—	+9.5	+9.5	—	+9.0	+9.0	−3.4	−2.7	−7.5	−6.5
+20	0	—	−4.5	−5.5	—	−3.4	−4.2	0.0	0.0	0.0	0.0
	1	—	+3.5	0.0	—	+8.7	+1.0	15.6	18.2	12.3	13.7
	2	—	+5.7	+2.5	—	+15.2	+5.7	21.2	25.2	15.7	17.1
	3	—	+17.5	+15.5	—	+18.0	+18.0	26.4	30.1	19.8	21.4
	24	—	+20.0	+20.0	—	+19.5	+19.5	−7.4	−6.2	−8.9	−7.7
+30	0	—	−4.5	−4.5	—	−3.8	−4.7	0.0	0.0	0.0	0.0
	1	—	+9.2	+5.4	—	+10.5	+5.5	18.4	13.2	14.6	10.8
	2	—	+24.3	+21.3	—	+21.3	+19.5	30.1	26.4	22.5	20.9
	24	—	+27.5	+27.5	—	+29.4	+29.4	−9.5	−9.5	−11.2	−12.7

* The pH value of the sample of contractile type in unfrozen state is 6.25 and that of non-contractile type in unfrozen state is 5.70, in both descending side.

months, then, the test pieces as above were cut from them and thawed by the following methods.

a. Influence of Air Velocity in Moving Air Defrosting upon Drip.

Frozen test pieces were thawed in moving air at 0, 1, 2.5 and 4 m/sec of velocity and +20°C of temperature respectively for hours for measuring each value. The results are given in Table 4.

In spite of remarkable differences observed between the meats of contractile and non-contractile types, marked differences were not found between the meats thawed in 0, 1, 2.5 and 4 m/sec of air velocity. But the higher was the air velocity, the larger were the moisture evapration as well as colour retardation on the surface of test pieces during thawing. Anyway this defrosting process is not appropriate for the frozen whalemeat.

b. Influence of Water Temperature in Still Water Defrosting upon Drip.

Frozen test pieces were thawed in still water at +5, +10, +20 and +30°C of temperature respectively for hours for measuring each value. But as drip was flown away in water, the value of weight loss of test pieces instead of drip value was measured. The results are given in Table 5.

Any remarkable differences were not observed between the meats of contractile and non-contractile types thawed at +5, +10, +20 and +30°C of water temperature. Defrosted meats had tissues bruised extensively, surfaces much

Table 6. Influence of water velocity in moving water defrosting upon drip (at +20°C of water temperature).*

Water velocity m/sec	Defrosting time h	Body temperature of meat °C						Thickness contraction %		Weight loss %	
		contractile type			non-contractile type			contractile type	non-contractile type	contractile type	non-contractile type
		surface	intermediate	center	surface	intermediate	center				
0.00	0	—	−4.0	−4.2	—	−3.5	−4.2	0.0	0.0	0.0	0.0
	1	—	0.0	−1.0	—	+1.0	−1.0	6.3	5.4	4.1	3.6
	2	—	+4.0	+1.5	—	+10.0	0.0	21.5	22.3	16.5	16.6
	3	—	+19.0	+19.0	—	+18.0	+17.0	27.1	29.5	21.0	22.9
0.09	0	—	−4.0	−4.5	—	−4.0	−4.2	0.0	0.0	0.0	0.0
	1	—	+5.0	+1.0	—	+8.5	+1.0	18.4	15.3	15.9	13.4
	2	—	+20.0	+20.0	—	+18.0	+18.0	24.4	27.2	20.1	20.3
0.20	0	—	−4.2	−4.5	—	−4.0	−4.5	0.0	0.0	0.0	0.0
	1	—	+6.0	+0.8	—	+12.5	+2.0	19.5	15.3	14.2	10.9
	2	—	+20.0	+20.0	—	+19.0	+18.0	24.4	19.5	18.1	17.3
0.36	0	—	−4.5	−5.0	—	−4.5	−5.0	0.0	0.0	0.0	0.0
	1	—	+7.0	+0.2	—	+12.0	+6.0	16.2	13.5	14.5	11.6
	2	—	+20.0	+20.0	—	+19.0	+19.0	27.7	18.9	19.8	15.6

* The pH value of the sample of contractile type in unfrozen state is 6.25 and that of non-contractile type in unfrozen state is 5.70, in both descending side.

whitened, the discolouration extending deep into the interior, and tastes quite flattened. Therefore, this defrosting process is not good for such frozen filleted meat as whalemeat.

c. Influence of Water Velocity in Moving Water Defrosting upon Drip.

Frozen test pieces were thawed in moving water at 0.00, 0.09, 0.20 and 0.36 m/sec of velocity and +20°C of temperature respectively for hours for measuring each value. But as drip was flown away in water, the value of weight loss of test pieces instead of drip value was measured also. The results are given in Table 6.

Any marked differences were not found between the meats of contractile and non-contractile types thawed at 0.00, 0.09, 0.20 and 0.36 m/sec of water velocity. Defrosted meats had tissues bruised extensively, the surfaces much whitened, the discolouration extending deep into the interior, and tastes quite flattened also. Therefore, this defrosting process is not good for such frozen filleted meat as whalemeat.

d. Influence of Salt Concentration in Still NaCl Brine Defrosting upon Drip.

Frozen test pieces were thawed in still NaCl brine at 0, 5, 15 and 25% of

Table 7. Influence of salt concentration in still NaCl brine defrosting upon drip (at +20°C of brine temperature).*

NaCl concentration %	Defrosting time h	Body temperature of meat °C						Thickness contraction %		Weight loss %	
		contractile type			non-contractile type			contractile type	non-contractile type	contractile type	non-contractile type
		surface	intermediate	center	surface	intermediate	center				
0	0	—	−2.7	−3.5	—	−3.7	−4.7	0.0	0.0	0.0	0.0
	1	—	+3.0	−0.5	—	+3.5	0.0	12.3	8.6	9.9	6.2
	2	—	+8.5	+5.6	—	+14.2	+8.6	21.5	15.3	15.6	12.7
	3	—	+15.4	+14.4	—	+18.0	+17.0	39.2	21.5	27.3	17.4
	24	—	+20.0	+20.0	—	+20.0	+20.0	1.3	−4.4	−2.5	−5.4
5	0	—	−2.0	−3.0	—	−3.5	−4.0	0.0	0.0	0.0	0.0
	1	—	+4.5	0.0	—	+2.0	−1.0	8.0	7.8	7.6	7.0
	2	—	+12.2	+8.7	—	+15.0	+10.0	12.4	11.5	9.7	9.7
	3	—	+16.2	+15.8	—	+19.0	+18.0	13.2	13.7	10.9	10.9
	24	—	+20.0	+20.0	—	+20.0	+20.0	16.8	15.9	13.3	12.5
15	0	—	−2.5	−3.5	—	−3.5	−4.0	0.0	0.0	0.0	0.0
	1	—	+6.0	−1.0	—	+3.5	−2.0	7.4	5.1	7.4	3.6
	2	—	+14.5	+10.0	—	+15.0	+6.0	12.3	8.4	9.5	6.0
	3	—	+17.2	+17.0	—	+19.0	+18.0	14.5	8.4	10.7	6.0
	24	—	+19.5	+19.5	—	+19.0	+19.0	15.2	8.4	12.4	6.0
25	0	—	−3.0	−4.0	—	−3.8	−4.2	0.0	0.0	0.0	0.0
	1	—	+5.0	−1.0	—	+3.0	−1.5	5.3	5.9	3.4	3.8
	2	—	+12.5	+9.2	—	+12.0	+8.8	5.5	8.2	5.0	6.5
	3	—	+16.0	+15.8	—	+17.0	+16.5	6.4	9.2	5.6	7.4
	24	—	+19.8	+19.8	—	+19.0	+19.0	11.1	9.2	8.7	8.3

* The pH value of the sample of contractile type in unfrozen state is 6.25 and that of non-contractile type in unfrozen state is 5.70, in both descending side.

NaCl concentration and +20°C of brine temperature respectively for hours for measuring each value. But again as drip was flown away in brine, the value of weight loss of test pieces instead of drip value was measured. The results are given in Table 7.

In spite of remarkable differences not observed between the meats of contractile and non-contractile types, marked differences were found between the meats thawed at 0, 5, 15 and 25% of NaCl concentration. The higher was the NaCl concentration, the less was the value of weight loss of meats of both contractile and non-contractile types. But defrosted meats at the high NaCl concentration had tissues dark coloured extensively, the discolouration extending deep into the interior, and tastes quite salty. Therefore, this defrosting process is not good for frozen whalemeat.

e. Influence of Ice Defrosting upon Drip.

Frozen test pieces were thawed by crushed ice in cold room of temperature 0°C for hours for measuring each value. But as drip was flown away in crushed ice, the value of weight loss of test pieces instead of drip value was measured. The results are given in Table 8.

Table 8. Influence of ice defrosting upon drip.*

Defrosting time h	Body temperature of meat °C						Thickness contraction %		Weight loss %	
	contractile type			non-contractile type						
	surface	intermediate	center	surface	intermediate	center	contractile type	non-contractile type	contractile type	non-contractile type
0	−3.0	−4.0	−5.0	−3.5	−4.5	−5.5	0.0	0.0	0.0	0.0
1	−2.0	−3.0	−4.0	−2.5	−4.0	−4.5	0.0	0.0	0.0	0.0
2	−1.0	−2.0	−3.0	−2.0	−3.0	−3.5	0.0	0.0	0.0	0.0
3	−1.0	−1.5	−2.0	−1.0	−2.0	−2.5	0.0	0.0	0.0	0.0
4	−1.0	−1.5	−2.0	−1.0	−2.0	−2.5	0.0	0.0	0.0	0.0
5	−1.0	−1.5	−1.5	−1.0	−1.5	−2.0	0.0	0.0	0.0	0.0
6	−1.0	−1.0	−1.0	0.0	−1.0	−1.5	0.0	0.0	0.0	0.0
7	−1.0	−1.0	−1.0	0.0	−1.0	−1.5	0.0	0.0	0.0	0.0
8	0.0	−1.0	−1.0	0.0	−1.0	−1.0	0.0	0.0	0.0	0.0
9	0.0	−1.0	−1.0	0.0	−1.0	−1.0	0.0	0.0	0.0	0.0
10	0.0	−1.0	−1.0	0.0	−1.0	−1.0	0.0	0.0	0.0	0.0
24	0.0	−1.0	−1.0	0.0	−1.0	−1.0	18.2	8.4	10.2	4.7

* The pH value of the sample of contractile type in unfrozen state is 6.25 and that of non-contractile type in unfrozen state is 5.70, in both descending side.

Marked differences were found between the meats of contractile and non-contractile types, but the value of weight loss was quite less than that thawed by other defrosting processes. Defrosted meats had somewhat the same tissues, surfaces and tastes as defrosted meats thawed in still water, because the meats were soaking in melted ice during thawing. Further, defrosting time of this method is too long. Therefore, this defrosting process is not good and practical for such frozen filleted meat as whalemeat.

f. Influence of Electric Defrosting upon Drip.

1) Influence of Electric Defrosting by Joule's Heat upon Drip.

100 volt 50 cycle A. C. was applied to the frozen test pieces through thin copper sheets on both sides and thawed by Joule's heat for minutes for measuring each value. The results are given in Table 9.

Table 9. Influence of electric defrosting by Joule's heat upon drip (100 volt 50 cycle A.C., direct contact to pole plates made with thin copper sheets).*

Defrosting time m	Body temperature of meat °C						Thickness contraction %		Drip %	
	contractile type			non-contractile type			contractile type	non-contractile type	contractile type	non-contractile type
	surface	intermediate	center	surface	intermediate	center				
0	—	−4.3	−4.7	—	−3.2	−3.8	—	—	—	—
1	—	−3.0	−1.5	—	−2.5	−2.0	—	—	—	—
2	—	−2.1	0.0	—	−1.5	−1.5	—	—	—	—
3	—	0.0	+1.0	—	−1.0	−1.0	—	—	—	—
4	—	+2.5	+3.4	—	0.0	+1.0	—	—	—	—
5	—	+7.8	+11.5	—	+5.4	+7.8	17.5	7.2	9.2	3.5
2 hrs. standing at +20°C	—	—	—	—	—	—	29.8	11.4	15.4	7.2

* The pH value of the sample of contractile type in unfrozen state is 6.25 and that of non-contractile type in unfrozen state is 5.70, in both descending side.

Remarkable differences were observed between the meats of contractile and non-contractile types, but the drip value was quite less than that thawed by other defrosting processes. Little damage was caused to the tissues, but defrosted meats retained good colour and flavour. If the procedure is followed carefully, the thawing will proceed fairly uniformly throughout the whole thickness except some partial overheating at the surface. But this process is so dangerous that this defrosting method is not practical for frozen whalemeat.

2) Influence of Electric Defrosting by Dielectric Heat upon Drip.

Frozen test pieces with thin mica sheets on both sides were inserted between pole plates and a high frequency electric potential of 14 Mc was applied to the plates to heat the frozen meats dielectrically for minutes for measuring each value. The results are given in Table 10.

Marked differences were found between the meats of contractile and non-contractile types, but the drip value was quite less than that thawed by other defrosting processes. The thawing proceeded nearly evenly throughout the whole thickness with no bruising in the meat tissues. Defrosted meats retained almost perfectly the excellent colour, the elastic firmness and the good palatability of the original raw meats. Therefore, this defrosting process is the best method for frozen whalemeat.

Table 10. Influence of electric defrosting by dielectric heat upon drip (14 Mc., indirect contact to pole plates through thin mica sheet).*

Defrosting time m	Body temperature of meat °C						Thickness contraction %		Drip %	
	contractile type			non-contractile type			contractile type	non-contractile type	contractile type	non-contractile type
	surface	intermediate	center	surface	intermediate	center				
0	—	−4.0	−4.7	—	−5.0	−5.0	—	—	—	—
1	—	−2.5	−0.2	—	−2.0	−2.0	—	—	—	—
2	—	−1.0	+3.0	—	−1.1	−1.4	—	—	—	—
3	—	+2.2	+8.0	—	−0.5	−0.9	—	—	—	—
4	—	+6.5	+11.8	—	0.0	0.0	—	—	—	—
5	—	+9.3	+15.4	—	+1.0	+3.0	6.0	2.2	4.8	1.3
2 hrs. standing at +20°C	—	—	—	—	—	—	12.5	7.4	9.1	5.6

* The pH value of the sample of contractile type in unfrozen state is 6.25 and that of non-contractile type in unfrozen state is 5.70, in both descending side.

Conclusion

To obtain the frozen whalemeat with small amount of drip and superior quality, it is concluded that the influences of change of storage temperature as well as the refreezing and rethawing are not so large. But considering the weight loss of frozen whalemeat due to moisture evaporation, these treatments may not be done. Dielectric heating is recommended as an excellent defrosting process for the frozen whalemeat of both contractile and non-contractile types, because it reproduces almost nearly the original quality of raw meats. But still air defrosting at +10°C or so of temperature is none the less practical. On the contrary, such frozen filleted meat as whalemeat must not be defrosted in water or brine.

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shape of about 0.05×0.10×0.15 m in size of roughly 0.75 kg in weight, were cut from them, and thawed in still air at +20°C. During thawing, both drip value and pH value of drip were measured on each test piece. The results are given in Table 1.

Any remarkable differences were not observed between the meats with and without bleeding. Taking into consideration of the change of pH value and drip value, it is presumed that the formers were gradually turned to non-contractile (post-rigor) type during bleeding while the latter was not. Therefore, if the meats are standing with the object of bleeding for too long time, it may be afraid, of producing disgustful odour though its drip value is to some extent decreased.

Two of the whole round skip-jack of post-rigor type, about 0.09×0.12×0.45 m in size and roughly 2 kg in weight were bled and precooled in sea water at about 0°C or so for 4 and 2 hours respectively while another fish was not bled and precooled. The temperatures of the central part of the formers were finally attained to +4°C and +8°C or so respectively but that of the latter still retained at +24°C or so. Then the fishes both with and without bleeding were frozen in an air-sharp type freezer by still air of temperature −22°C for 6.5, 6.5 and 8.5 hours or so respectively. After freezing, the frozen fishes were glazed and stored at −15°C or so for about one month, then, thawed in still air at +20°C. During thawing, drip value was measured and organoleptic test was carried on each sample. The results are given in Table 2.

Table 2. Effect of bleeding process before freezing upon quality of frozen skip-jack.

Bleeding time hrs.	Drip %	
	in 8 hrs.	in 24 hrs.
0	1.7	2.1
2	1.6	1.8
4	2.0	2.2

Any marked differences were not found between the fishes with and without bleeding.

These experimental results lead us to the conclusion that to reduce the drip value and maintain the high quality of frozen whalemeat and whole round skip-jack, the bleeding process before freezing may not be always necessary though sometimes it acts as a good washing of the meat and the fish.

2. Protective Effect of Glazing and Packaging Materials after Freezing against Moisture Evaporation of Frozen Whalemeat and Skip-jack during Cold Storage.

a. Protective Effect of Glazing.

Frozen blocks of lean meat of fin whales of both contractile (pre-rigor) and non-contractile (post-rigor) types, having a rectangular shape of about 0.12×0.30×0.39 m in size and roughly 15 kg in weight, as well as frozen whole round skip-jack of both full-rigor and post-rigor types, about 0.09×0.12×0.45 m in size

and roughly 2 kg in weight were taken out of the freezer and attaining a temperature of −15°C in the central part were dipped in not only fresh water (of 0°C freezing point) but also sea water (of −2°C freezing point) cooled at +2°C, for 3 seconds, 3 times each, at 5 minutes intervals in cold room at −5°C and glazed. After glazing, the frozen whalemeats were stored in cold room kept at −20°C or so and the frozen whole round skip-jack were stored in cold room kept at −15°C or so for months respectively. Then, loss of glazing due to evaporation was measured at the end of each definite period of storage. Simultaneously loss of weight of both frozen whalemeat and whole round skip-jack without glazing due to moisture evaporation were also measured at the same period of storage. These values of not only glazing adhered to the frozen sample after freezing but also loss of glazing and loss of weight of the frozen samples without glazing during storage were all expressed as percentage with the original weight of frozen whalemeat and skip-jack. The results are given in Table 3 and Table 4.

Table 3. Amount of fresh water and sea water glazing adhered to frozen whalemeat and skip-jack.

Fresh water glazing %

Dipped time	Frozen Whalemeat		Frozen Skip-jack	
	Contractile type (16.100 kg of original wt.)	Non-contractile type (15.320 kg of original wt.)	Full-rigor type (1.975 kg of original wt.)	Post-rigor type (2.150 kg of original wt.)
1	1.93	1.76	3.04	2.33
2	3.29	3.07	5.06	4.65
3	4.04	3.85	7.09	6.51
2-1	1.36	1.31	2.02	2.32
3-2	0.75	0.78	2.03	1.86

Sea water glazing %

Dipped time	Frozen Whalemeat		Frozen Skip-jack	
	Contractile type (15.820 kg of original wt.)	Non-contractile type (16.340 kg of original wt.)	Full-rigor type (2.065 kg of original wt.)	Post-rigor type (1.845 kg of original wt.)
1	1.39	1.77	1.94	1.63
2	2.02	2.45	2.91	3.25
3	2.59	3.06	3.87	4.34
2-1	0.63	0.68	0.97	1.62
3-2	0.57	0.61	0.96	1.09

From the experimental results of Table 3, any remarkable differences are not observed on amount of glazing adhered to the samples of between contractile (pre-rigor) and non-contractile (post-rigor) types of frozen whalemeat as well as of between full-rigor and post-rigor types of frozen whole round skip-jack. It is presumed that the lower the temperatures of frozen sample, glazing water and glazing room are, the more amount of glazing adhered to

Table 4. Amount of loss of fresh water and sea water glazing and loss of weight of frozen whalemeat and skip-jack without glazing due to evaporation during cold storage.

Storage period m	Non-glazing %			
	Frozen Whalemeat		Frozen Skip-jack	
	Contractile type (17.230 kg of original wt.)	Non-contractile type (15.670 kg of original wt.)	Full-rigor type (2.135 kg of original wt.)	Post-rigor type (1.940 kg of original wt.)
0	0.00	0.00	0.00	0.00
1	0.12	0.19	0.47	0.26
2	0.32	0.48	0.70	0.77
3	0.61	0.73	0.94	1.03
6	1.19	1.34	1.41	1.29
9	1.42	1.63	2.11	2.06
12	1.65	1.82	2.58	2.84

Storage period m	Fresh water glazing %			
	Frozen Whalemeat		Frozen Skip-jack	
	Contractile type	Non-contractile type	Full-rigor type	Post-rigor type
0	0.00	0.00	0.00	0.00
1	0.37	0.42	0.51	0.47
2	0.59	0.52	0.76	0.70
3	0.84	0.78	1.01	0.93
6	1.27	1.31	1.77	1.40
9	1.74	1.80	2.28	1.86
12	1.96	2.09	3.04	3.02

Storage period m	Sea water glazing %			
	Frozen Whalemeat		Frozen Skip-jack	
	Contractile type	Non-contractile type	Full-rigor type	Post-rigor type
0	0.00	0.00	0.00	0.00
1	0.25	0.28	0.24	0.27
2	0.41	0.46	0.48	0.54
3	0.66	0.70	0.73	0.81
6	1.14	1.25	1.21	1.08
9	1.64	1.77	1.94	1.63
12	1.77	1.90	2.42	2.44

frozen goods increases. The amount of sea water glazing is less than that of fresh water glazing and the former is about 70% of the latter under the same conditions. Sea water glazing has a tendency to be opaque and off from the frozen goods compared with fresh water glazing having transparent and sticky characters. The amount of fresh water glazing or sea water glazing dipped at the 2nd time is less than that of the first time, and the former is about 80% of the latter. Again, the amount of fresh water glazing or sea water glazing dipped at the 3rd time is also less than that of the 2nd time, and the former is about 75% of the latter.

From the experimental results of Table 4, the amount of loss of glazing and loss of weight of frozen samples without glazing due to moisture evapora-

tion during cold storage are not so much, i.e. within 2% in frozen whalemeat of both contractile (pre-rigor) and non-contractile (post-rigor) types stored at −20°C and within 3% in frozen whole round skip-jack of both full-rigor and post-rigor types stored at −15°C after a year. It is presumed that the lower the storage temperature, the less is the loss of glazing and loss of weight of frozen goods due to moisture evaporation. The amount of loss of weight of the frozen samples without glazing due to moisture evaporation is less than that of fresh water glazing, and the former is about 80% of the latter at each period of storage. Again, the amount of loss of sea water glazing is less than that of fresh water glazing, and the former is about 80% of the latter at each period of storage. Here, in any cases the sea water glazing was quite excellent as well as fresh water glazing. With the view that the amount of loss of glazing from the frozen sample due to evaporation during cold storage is always less than that of glazing adhered to the frozen samples after freezing, it is clear that the glazing on surface of all samples was fully in tact even after a year. However, an evaporation of glazing during cold storage is not evenly occurred from all the surfaces of frozen goods, but it is partially disappeared from such pointed parts as corner, end, snout and tail of frozen whalemeat and whole round skip-jack. Partial disappearance of glazing as above was found out in the frozen whalemeat after nine months as well as in the frozen whole round skip-jack after six months of storage. The shrinkage due to moisture evaporation and slight rusting due to fat oxidation of frozen samples during cold storage were gradually proceeded as soon as partial disappearance of glazing was occurred, but these surface deterioration was not found at all in part of surface fully glazed even after a year.

Continuously, to increase the amount of glazing adhered to frozen goods following experiments of colloidal glazing were carried out.

Frozen blocks of lean meat of fin whales of non-contractile (post-rigor) type, having a rectangular shape of about $0.044 \times 0.084 \times 0.124$ m in size and roughly 0.45 kg (≒1 lb) in weight were taken out of the freezer and attaining a temperature of −12°C in the central part were dipped in some colloidal solutions (of about 0°C freezing point in all solutions) at 1/3, 2/3 and 1% of colloidal concentrations (but at 1/30, 2/30 and 1/10% in agar-agar solution) cooled at +2°C, for 3 seconds, 3 times each, at 5 minutes intervals in cold room at −5°C and glazed. After glazing, the frozen meats were stored in cold room kept at −14°C or so for months. Then, loss of glazing due to evaporation was measured at the end of each definite period of storage. Simultaneously loss of water glazing and loss of weight of the frozen meat without glazing due to moisture evaporation were also measured at the same period of storage. The results are given in Table 5 and Table 6.

From the experimental results of Table 5, it is clear that the amount of colloidal glazing adhered to the frozen whalemeat is much more than that of fresh water glazing adhered to the frozen one at above definite concentration of colloidal solutions, but any differences are not found on the amount of glazing at below this definite concentration of colloidal solutions. Sometimes, colloidal glazing has a tendency to be opaque, uneven and off from the frozen goods in a block.

Table 5. Amount of colloidal glazing adhered to frozen whalemeat.

Dipped time	Fresh water glazing % (0.745 kg of original wt.)
1	2.15
2	3.76
3	5.10
2–1	1.61
3–2	1.34

Dipped time	Gelatine glazing %			Glue glazing %		
	1/3% (0.805 kg of original wt.)	2/3% (0.771 kg of original wt.)	1% (0.619 kg of original wt.)	1/3% (0.737 kg of original wt.)	2/3% (0.489 kg of original wt.)	1% (0.630 kg of original wt.)
1	2.11	1.95	2.58	1.49	2.25	3.02
2	2.98	3.37	5.01	2.04	3.48	5.24
3	3.85	4.41	6.62	2.71	4.70	7.14
2–1	0.87	1.42	2.43	0.55	1.23	2.22
3–2	0.87	1.04	1.61	0.67	1.22	1.90

Dipped time	Starch glazing %			CMC (Carboxy Methyl Cellulose) glazing %		
	1/3% (0.603 kg of original wt.)	2/3% (0.539 kg of original wt.)	1% (0.641 kg of original wt.)	1/3% (0.887 kg of original wt.)	2/3% (0.631 kg of original wt.)	1% (0.575 kg of original wt.)
1	0.83	2.23	2.96	1.80	4.60	7.13
2	1.49	3.34	5.15	3.38	6.50	12.17
3	1.99	4.08	6.40	4.40	8.72	14.96
2–1	0.66	1.11	2.19	1.58	1.90	5.04
3–2	0.50	0.74	1.25	1.02	2.22	2.79

Dipped time	Agar-agar (Sea-weed isinglass) glazing %			Sea-weed glue glazing %		
	1/30% (0.805 kg of original wt.)	2/30% (0.588 kg of original wt.)	1/10% (0.820 kg of original wt.)	1/3% (0.857 kg of original wt.)	2/3% (0.689 kg of original wt.)	1% (0.451 kg of original wt.)
1	1.49	1.53	2.68	3.50	6.39	7.98
2	2.73	2.72	4.51	5.72	10.30	12.64
3	3.60	4.08	5.98	7.23	12.77	13.75
2–1	1.24	1.19	1.83	2.22	3.91	4.66
3–2	0.87	1.36	1.47	1.51	2.47	1.11

Dipped time	Alginic acid glazing %			Polyvinyl alcohol glazing %		
	1/3% (0.789 kg of original wt.)	2/3% (0.666 kg of original wt.)	1% (0.699 kg of original wt.)	1/3% (0.687 kg of original wt.)	2/3% (0.723 kg of original wt.)	1% (0.550 kg of original wt.)
1	1.90	3.30	3.86	2.62	2.07	3.09
2	3.68	6.01	7.15	4.66	3.87	5.27
3	5.07	7.66	9.59	5.97	5.26	7.09
2–1	1.78	2.71	3.29	2.04	1.80	2.18
3–2	1.39	1.65	2.44	1.31	1.39	1.82

Table 6. Amount of loss of colloidal glazing and loss of weight of frozen whalemeat without glazing due to evaporation during cold storage.

Storage period m	Non-glazing % (0.623 kg of original wt.)	Water glazing %
0	0.00	0.00
1	0.48	0.54
2	0.80	0.94
3	1.28	1.61
6	2.41	3.22
9	3.69	4.56
12	4.65	6.04

Storage period m	Gelatine glazing %			Glue glazing %			Starch glazing %			CMC (Carboxy Methyl Cellulose) glazing %		
	1/3%	2/3%	1%	1/3%	2/3%	1%	1/3%	2/3%	1%	1/3%	2/3%	1%
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.99	0.78	0.65	0.95	1.23	0.95	0.50	0.56	0.78	1.13	0.95	1.74
2	1.12	0.91	0.81	0.95	1.64	1.27	0.66	0.74	0.94	1.13	1.27	2.09
3	1.37	1.43	1.13	1.63	2.04	2.06	0.83	1.30	1.40	2.25	2.38	2.96
6	2.98	2.72	2.58	3.39	4.09	4.13	1.82	2.41	2.81	4.62	4.44	4.87
9	4.22	4.15	4.04	5.02	5.32	5.40	2.49	4.08	3.90	5.07	5.55	6.61
12	5.71	5.58	5.49	6.65	6.95	6.98	2.99	5.75	5.93	5.75	6.66	7.83

Storage period m	Agar-agar (Sea-weed isinglass) glazing %			Sea-weed glue glazing %			Alginic acid glazing %			Polyvinyl alcohol glazing %		
	1/30%	2/30%	1/10%	1/3%	2/3%	1%	1/3%	2/3%	1%	1/3%	2/3%	1%
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.75	1.02	0.61	1.05	1.31	1.33	1.27	1.35	1.00	1.31	1.38	1.82
2	0.75	1.02	0.73	1.40	1.74	2.00	1.52	1.50	1.29	2.33	1.52	2.00
3	1.24	1.36	0.85	2.45	2.90	3.33	2.53	2.55	2.29	2.91	2.07	2.55
6	2.36	2.21	2.07	4.90	6.10	6.65	4.82	3.30	4.15	4.80	4.15	4.55
9	4.10	4.08	3.54	5.83	6.97	7.54	6.21	5.41	6.01	6.70	6.22	5.45
12	5.22	5.27	4.02	6.30	8.13	8.65	7.98	7.81	6.87	9.02	7.47	7.82

From the experimental results of Table 6, any differences are not observed on the amount of loss of glazing between colloidal and fresh water glazing due to evaporation during storage. On the whole, in this experiment the amount of loss of glazing is more than that in previous experiment. The reason of this fact is supposed to be, due to the previous experiment was carried out at the inner part of large cold room where the temperature fluctuation was not much, on the other hand, this experiment was done at the entrance of little cold room where the temperature fluctuation was much. Recommended colloidal solutions for glazing are that of colloidal concentration above 1% of glue, starch, CMC and alginic acid.

b. Protective Effect of Packaging Materials.

Frozen blocks of lean meat of fin whales of non-contractile (post-rigor) type, having a rectangular shape of about $0.044 \times 0.084 \times 0.124$ m in size and roughly 0.45 kg (≒1 lb) in weight were taken in bags made of some thickness

of film, of so-called inner and outer packaging materials, a regular square shape of 0.20×0.20 m in size, and sealed their mouth after discharging the air in the bags by hand as far as possible and wrapped. After wrapping, the test pieces were stored in cold room kept at $-8°C$ for months. Then, loss of weight of frozen whalemeat due to moisture evaporation through these packaging materials was measured at the end of each definite period of storage. Simultaneously loss of weight of frozen whalemeat without packaging materials due to moisture evaporation was also measured at the same period of storage. These values of not only packaging materials used to the frozen sample after freezing but also loss of weight of sample during storage, were all expressed as percentage with the original weight of the frozen whalemeat. The results are given in Table 7.

Table 7. Amount of loss of weight of frozen whalemeat due to moisture evaporation through packaging material during cold storage.

Storage period m	Moisture Vapour Proof Cellophane of Du Pont MSAT %			Moisture Vapour Proof Cellophane of Neocherryphane %		
	No. 600 (0.505 kg of original wt. and 1.98% of material)	No. 450 (0.394 kg of original wt. and 1.27% of material)	No. 300 (0.445 kg of original wt. and 0.67% of material)	No. 400 (0.676 kg of original wt. and 0.44% of material)	No. 300 (0.640 kg of original wt. and 0.31% of material)	No. 300 (0.636 kg of original wt. and 0.47% of material)
0	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.44	0.00	0.00
2	0.00	0.00	0.00	0.44	0.16	0.00
3	0.00	0.00	0.00	1.04	0.47	0.31
6	2.57	2.28	1.80	1.04	0.94	0.79
9	3.37	3.05	2.92	3.25	2.34	2.20
12	3.37	3.05	2.92	4.29	3.13	2.67
% of snow in bag after a year	2.18	2.28	2.47	0.89	0.94	2.36

Storage period m	Moisture Vapour Proof Cellophane of Cellusee %	Moisture Vapour Proof Cellophane of Toucello %		Moisture Vapour Proof Cellophane of Sunphan %	Non-Packaging %
	No. 300 (0.605 kg of original wt. and 0.50% of material)	No. 300 (0.541 kg of original wt. and 0.74% of material)	No. 300 (0.604 kg of original wt. and 0.50% of material)	No. 300 (0.528 kg of original wt. and 0.76% of material)	(0.723 kg of original wt.)
0	0.00	0.00	0.00	0.00	0.00
1	0.00	0.55	0.00	0.00	2.90
2	0.17	0.74	0.00	0.00	4.98
3	1.98	1.85	0.00	0.00	8.44
6	2.81	2.59	0.83	0.00	10.65
9	6.45	5.18	1.49	1.33	12.45
12	8.76	7.21	3.64	1.89	14.94
% of snow in bag after a year	0.83	0.55	1.32	3.60	0.00

Storage period m	Polyethylene %			Vinyl %	Saran %	
	0.15 mm (0.460 kg of original wt. and 3.48% of material)	0.10 mm (0.463 kg of original wt. and 1.94% of material)	0.04 mm (0.507 kg of original wt. and 0.99% of material)	(0.448 kg of original wt. and 2.23% of material)	Transparent (0.458 kg of original wt. and 0.87% of material)	Opaque (0.455 kg of original wt. and 1.98% of material)
0	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00
% of snow in bag after a year	2.17	3.67	3.55	2.68	5.90	1.54

Storage period m	Cryovac %	Pliofilm %	Ryphan %	Tarpaulin paper %
	(0.459 kg of original wt. and 2.18% of material)	(0.403 kg of original wt. and 0.74% of material)	(0.450 kg of original wt. and 0.44% of material)	(0.510 kg of original wt. and 1.96% of material)
0	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00
% of snow in bag after a year	4.58	8.68	2.22	3.73

Storage period m	Ordinary Cellophane %			Parchment paper %		
	No. 600 (0.385 kg of original wt. and 1.56% of material)	No. 450 (0.413 kg of original wt. and 0.97% of material)	No. 300 (0.446 kg of original wt. and 0.67% of material)	No. 50 (0.413 kg of original wt. and 1.45% of material)	No. 40 (0.398 kg of original wt. and 1.26% of material)	No. 30 (0.451 kg of original wt. and 1.11% of material)
0	0.00	0.00	0.00	0.00	0.00	0.00
1	1.56	1.45	1.35	1.45	2.51	1.11
2	2.08	2.18	2.02	2.18	3.27	1.55
3	2.86	2.66	2.47	3.15	4.02	2.00
6	7.53	7.51	6.73	7.26	5.78	5.76
9	9.87	9.69	7.85	9.20	7.29	6.65
12	9.87	9.69	8.30	9.20	7.54	7.32
% of snow in bag after a year	0.00	0.00	0.00	0.00	0.00	0.00

It is clear that the loss of weight of frozen whalemeat due to moisture evaporation during cold storage is perfectly protected with film of so-called inner packaging materials, but only partially protected with so-called outer packaging materials. However, comparatively large amount of snow due to condensation in bags made of so-called inner packaging materials was observed and the frozen whalemeat packed in those materials was found being much rusted due to fat

Storage period m	Melamin paper % (0.712 kg of original wt. and 0.56% of material)	Beckamin paper % (0.649 kg of original wt. and 0.46% of material)	Waxed paper % (0.597 kg of original wt. and 0.84% of material)	Kraft paper % (0.436 kg of original wt. and 4.36% of material)	Paper board % (0.435 kg of original wt. and 7.82% of material)
0	0.00	0.00	0.00	0.00	0.00
1	1.69	4.31	1.17	1.83	1.61
2	2.53	6.93	1.34	2.75	2.99
3	4.07	10.02	1.68	5.50	7.13
6	4.92	11.71	3.02	8.26	9.43
9	6.46	13.10	6.20	8.94	10.34
12	8.15	14.18	8.21	8.94	10.34
% of snow in bag after a year	0.00	0.00	0.00	0.00	0.00

Storage period m	Melamin coated kraft paper %		Polyethylene coated kraft paper %		Saran coated kraft paper %	
	No. 1 (0.562 kg of original wt. and 1.60% of material)	No. 2 (0.579 kg of original wt. and 2.42% of material)	No. 1 (0.583 kg of original wt. and 1.20% of material)	No. 2 (0.526 kg of original wt. and 2.28% of material)	No. 1 (0.780 kg of original wt. and 1.41% of material)	No. 2 (0.432 kg of original wt. and 3.24% of material)
0	0.00	0.00	0.00	0.00	0.00	0.00
1	1.78	1.73	0.00	0.00	0.00	0.00
2	1.96	1.73	0.00	0.00	0.00	0.00
3	2.85	2.76	0.00	0.00	0.00	0.00
6	3.74	3.97	0.00	0.00	0.00	0.00
9	4.80	6.74	0.00	0.00	0.00	0.00
12	6.94	10.54	0.00	0.00	0.00	0.00
% of snow in bag after a year	0.00	0.00	3.77	3.04	5.00	4.17

Storage period m	Melamin coated paper board %	
	No. 1 (0.612 kg of original wt. and 3.10% of material)	No. 2 (0.443 kg of original wt. and 4.97% of material)
0	0.00	0.00
1	1.47	1.81
2	1.63	2.93
3	2.45	4.29
6	3.76	6.77
9	5.07	6.77
12	7.03	6.77
% of snow in bag after a year	0.00	0.00

oxidation after a year. These experimental results lead us to the conclusion that the packaging materials especially inner ones can perfectly protect the loss of weight of frozen goods due to moisture evaporation, but cannot fully protect the rusting of frozen goods due to fat oxidation during cold storage.

Conclusion

To obtain the frozen whalemeat and the whole round skip-jack with small amount of drip and superior quality, the bleeding process before freezing may not be always necessary, but the glazing by both fresh water, sea water and colloidal solution after freezing is very effective to protect the loss of weight due to moisture evaporation and the rusting due to fat oxidation of the frozen goods during cold storage. Recommended colloidal solutions for glazing are that of colloidal concentration above 1% of glue, starch, CMC and alginic acid.

Both so-called inner and outer packaging materials are very effective to protect the loss of weight of frozen goods due to moisture evaporation, but not so effective to protect the rusting of frozen goods due to fat oxidation during cold storage.

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FREEZING, COLD STORAGE AND DEFROSTING OF WHOLE ROUND SKIP-JACK

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Introduction

In Japan, frozen whole round skip-jack (Katsuwonus pelamis (Linne)) is principal exposed frozen goods mainly for U.S.A. as a material of canned tuna (light meat). Check of deterioration and maintain of high quality of the frozen fish are important problems given to us. The author researched into the changes in the quality of the frozen fish during freezing, cold storage and defrosting. To obtain some proper measures on this line the author carried out the following experiments.

Experimental

1. Observation on State of Unfrozen Fish.

To investigate into the specific features of the unfrozen condition of the fish, changes in weep and pH values of meat were pursued on a sample just after capture. The whole round fish, measuring about $0.095 \times 0.125 \times 0.495$ m in size and roughly 2.25 kg in weight, was kept in still air at $+20°C$ for 3 days for the experiment. The results obtained are shown in Table 1.

Table 1. Changes in unfrozen whole round skip-jack (at $+20°C$).

Time hrs.	0	4	8	12	16	20	24	30	36	42	48	54	60	66	72
PH	6.08	5.99	5.88	5.75	5.54	5.58	5.65	5.68	5.71	5.80	5.94	6.07	6.17	6.30	6.38
Weep %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

The results of observation can be summarized as below:

Full-rigor state: At its pH value above 5.54 in descending side (the lowest pH value on this experiment) the tissues of the fish were observed to be in progress rigor. It was hard and dry to the touch with bright blackish white colour of the skin and bright blackish red colour of the muscle. No weep was exuded from the tissue.

Post-rigor state: At its pH value above 5.54 in ascending side the rigor of the tissues was resolved. It was soft and wet to the touch with dull bluish white colour of the skin and dull brownish red colour of the muscle. Again, no weep was exuded from the tissue and still it was edible. Thereafter, at pH value of 5.94 it turned quite inedible because of its putrefactive odour.

From these facts it can be presumed that the following expriments were better to be carried out on these two types of tissue of the fish, i.e. full-rigor

type and post-rigor type in unfrozen state. It was very difficult for us in land to get a fish with the tissue of pre-rigor type in unfrozen state.

2. Observation on Exudation of Drip from Frozen Whole Round Fish and Fish-fillet.

To inspect the quality of frozen fish muscle, the drip value is measured in this experiment. For this purpose the preliminary observation on drip value was carried out whether any differences for the exudation of drip from a frozen whole round fish or a cut fish-fillet can be found or not. The samples of whole round fish having as above size and weight (not eviscerated) were frozen in an air-sharp type freezer by still air of temperature −22°C for 8 hours or so. After freezing, the frozen fishes were glazed and stored at −15°C or so for about three months, then, the test pieces of fish-fillet (with the skin on one side and rectangular shape of about 0.03×0.10×0.15 m in size of roughly 0.45 kg in weight) were cut from one of the samples, and thawed them in still air at +20°C. During thawing, drip value was measured on each sample of both frozen whole round fish and fish-fillet. The results obtained are shown in Table 2.

Table 2. Difference in drip value exuded from between frozen whole round fish and fish-fillet of skip-jack.

Unfrozen state	Drip %						
	in 8 hrs.		in 24 hrs.		in 2.5 kg/cm²g.*		Total drips exuded from fish-fillet in 24 hrs. and 2.5 kg/cm²g.
	round fish	fish-fillet	round fish	fish-fillet	round fish	fish-fillet	
Full-rigor type	1.5	2.7	2.9	3.4	—	11.7	15.1
Post-rigor type	1.0	1.2	1.6	1.9	—	12.9	14.8

* Squeezing pressure: The expressible drip was exuded under pressure of 2.5 kg/cm²g. after 24 hrs. exudation of free drip.

Though slight differences observed between the full-rigor and post-rigor types, remarkable differences were not found between the whole round fish and fish-fillet on drip value exuded from the tissues. In Japan, the skip-jack is practically frozen in whole round. Therefore, the author carried out the following experiments on whole round fish both in full-rigor and post-rigor types. About 0.09×0.12×0.45 m in size and roughly 2 kg in weight were used for the experiments.

By the way, the constituents of the fish muscle of skip-jack used for these experiments and the drip exuded from its tissues, as obtained by chemical analysis, are shown in Table 3 and Table 4.

Table 3. Constituents of fish-muscle of skip-jack used for this experiment

Unfrozen state	Moisture %	Crude fat %	Crude protein %	Ash %
Full-rigor type	72.46	1.27	25.13	1.14
Post-rigor type	71.83	1.14	25.31	1.72

Table 4. Constituents of drip exuded from the tissue of skip-jack.

Unfrozen state	Moisture %	Crude fat %	Crude protein %	Ash %
Full-rigor type	84.60	0.33	13.06	2.01
Post-rigor type	84.17	0.77	13.19	1.87

3. Effect of Freezing Conditions upon Quality of Frozen Fish.

a. Effect of Initial Temperature of Fish When It Is Taken into Freezer upon Quality.

One of the fish as above (i.e. full-rigor and post-rigor types) was precooled first in air at about 0°C for 2 hours and further in sea water at about 0°C for 2 hours while the other was not precooled. The temperature of the central part of the former was finally attained to +5°C or so but that of the latter still retained at +25°C or so. Then the fish not only in full-rigor and post-rigor types but also with and without precooling were frozen in an air-sharp type freezer by still air of temperature −22°C for 6.5 and 8.5 hours or so respectively. After freezing, the frozen fish was glazed and stored at −15°C or so for about one month, then, thawed in still air at +20°C. During thawing, the drip value was measured and organoleptic test was carried on each samples. The results are given in Table 5.

Table 5. Effect of initial temperature of fish when it is taken into freezer upon quality.

Initial temp. °C	Drip %			
	in 8 hrs.		in 24 hrs.	
	full-rigor type	post-rigor type	full-rigor type	post-rigor type
+25 (Without precooling)	2.4	1.5	2.8	1.7
+ 5 (With precooling)	2.2	2.0	2.7	2.3

Any remarkable differences were not observed from the drip value between the fishes of full-rigor and post-rigor types with and without precooling. But organoleptically the quality of the fish of full-rigor type was considered as better than that of post-rigor type, and the low initial temperature of fish before freezing by precooling will be contributable to diminish the freezing time.

b. Effect of Freezing Rate of Fish upon Quality.

One of the fish as above was frozen in an air-sharp type freezer by still air of temperature −22°C (but the fish was put on a wooden plate over the cooling coil) for 12 hours while the other was frozen in a semi-air-blast type freezer by moving air of temperature −22°C and of velocity 4 m/sec for 4 hours. From these freezing time, the former is so-called slow-freezing and the latter quick-freezing. After freezing and cold storage at −15°C or so for about one month, the samples were thawed in still air at +20°C for measuring the drip value and observing the quality organoleptically. The results are given in Table 6.

Table 6. Effect of freezing rate of fish upon quality.

Freezing time hrs.	Drip %			
	in 8 hrs.		in 24 hrs.	
	full-rigor type	post-rigor type	full-rigor type	post-rigor type
12 (Slow-freezing)	3.2	2.4	3.5	2.6
4 (Quick-freezing)	2.8	1.8	3.2	2.0

Any marked differences were also not found from the drip value between the fishes of full-rigor and post-rigor types frozen slowly and quickly. But organoleptically the quality of the fish of full-rigor type was considered as better than that of post-rigor type, and as less time is required in quick-freezing than in slow-freezing, the capacity of the quick-freezer will be higher than that of the slow-freezer under same conditions.

Table 8. Effect of storage temper

Storage temp. °C	Storage period m	Loss of weight %		Drip %				pH	
				in 8 hrs.		in 24 hrs.		in drip	
		full-rigor type	post-rigor type	full-rigor type	post-rigor type	full-rigor type	post-rigor type	full-rigor type	post-rigor type
− 7	0	0.00	0.00	2.1	1.4	2.2	1.7	5.85	5.60
	1	0.27	0.27	3.3	2.1	3.5	2.5	5.40	5.70
	2	0.50	0.53	2.8	2.2	2.9	2.4	5.30	5.80
	3	0.92	1.02	1.4	3.1	2.5	3.4	5.20	5.80
	6	1.83	1.91	2.6	2.8	3.2	3.1	5.20	5.85
	9	2.94	3.07	3.4	3.4	4.2	3.7	5.85	6.05
	12	3.74	3.92	4.0	4.5	5.0	5.2	6.05	6.10
−14	0	0.00	0.00	2.1	1.4	2.2	1.7	5.85	5.60
	1	0.23	0.25	3.5	1.9	3.8	2.3	5.60	5.70
	2	0.60	0.85	2.7	2.4	2.9	2.5	5.60	5.75
	3	1.01	1.21	2.5	1.3	3.7	2.2	5.50	5.75
	6	1.61	1.67	1.9	1.5	2.7	1.8	5.30	5.75
	9	2.00	2.10	2.7	3.0	4.4	3.2	5.75	5.95
	12	2.56	2.53	3.1	4.0	4.0	4.2	5.85	6.00
−21	0	0.00	0.00	2.1	1.4	2.2	1.7	5.85	5.60
	1	0.00	0.00	2.7	1.5	2.9	1.6	5.70	5.60
	2	0.02	0.04	2.2	2.1	3.0	2.4	5.70	5.70
	3	0.09	0.08	2.4	2.2	2.8	2.4	5.70	5.70
	6	0.22	0.34	2.2	1.7	2.7	1.8	5.60	5.70
	9	0.26	0.49	4.8	2.7	5.6	3.0	5.65	5.85
	12	0.39	0.57	5.0	3.5	5.7	4.0	5.70	6.00

* In these samples of both full-rigor and post-rigor types at unfrozen state, pH value muscle 37.9 % and 32.6 %, protein N/total N in water extract from the muscle was 17.1 % and 17.9 %, respectively.

Table 7. Effect of final temperature of fish when it is taken out of freezer upon quality.

Final temp. °C	Drip %			
	in 8 hrs.		in 24 hrs.	
	full-rigor type	post-rigor type	full-rigor type	post-rigor type
− 5 (Comparatively high)	1.4	1.3	2.1	1.8
−20 (Comparatively low)	1.6	2.1	1.9	2.3

c. Effect of Final Temperature of Fish When It Is Taken out of Freezer upon Quality.

Types of fish as above were frozen in an air-sharp type freezer by still air of temperature −22°C until −5°C was the final temperature of the central part of the one and −20°C was that of the other for 6.5 and 8 hours or so

ature upon quality of frozen fish.*

souble total N / total N × 100 %		protein N / total N × 100 %				souble heat coagulable N / soluble total N × 100 %	
in muscle		in water extract from muscle		in drip		in water extract from muscle	
full-rigor type	post-rigor type	full-rigor type	post-rigor type	full-rigor type	post-rigor type	full-rigor type	post-rigor type
30.5	31.3	80.7	64.1	89.6	68.2	17.6	17.9
69.6	48.7	56.0	33.7	80.3	50.7	15.8	17.7
60.2	41.3	48.2	35.2	61.0	40.0	19.6	20.4
52.8	41.8	34.3	30.8	51.8	42.0	25.2	27.8
46.4	38.5	36.1	29.5	45.1	37.2	48.0	36.7
48.2	37.5	16.0	23.9	46.5	30.6	27.8	27.1
52.1	57.3	30.8	23.4	58.6	33.3	16.4	25.8
30.5	31.3	80.7	64.1	89.6	68.2	17.6	17.9
71.2	49.0	54 6	41.2	77.0	59.7	16.7	16.4
62.3	44.9	50.0	38.7	72.0	50.2	25.4	20.2
53.2	42.5	43.1	36.2	61.5	43.3	35.6	23.6
43.3	36.5	47.6	36.5	59.2	47.8	41.3	40.4
32.1	34.9	27.4	27.0	55.0	51.1	30.4	39.9
47.2	49.1	28.1	27.9	76.5	52.0	32.3	34.5
30.5	31.3	80.7	64.1	89.6	68.2	17.6	17.9
70.6	40.0	53 5	42.0	82.8	67.1	15.5	16.7
58.9	48.4	59.0	39.2	72.2	62.8	21.8	21.0
51.0	42.0	53.1	37.9	81.5	60.0	29.1	27.6
43.4	32.7	55.9	40.6	73.1	53.0	25.3	37.8
27.9	32.2	33.6	30.7	72.5	52.2	18.0	33.6
41.6	45.8	40.6	29.7	71.8	57.7	15.3	27.5

vas 5.95 in descending side and 5.70 in ascending side, soluble total N/total N in 1.6 % and 67.9 %, and heat coagulable N/total N in water extract from the muscle

respectively. After freezing and cold storage at −15°C or so for about one month, the samples were thawed in still air at +20°C for measuring the drip value and observing the quality organoleptically. The results are given in Table 7.

Again, any clear differences were not detected from the drip value between the fishes of full-rigor and post-rigor types with comparatively high and low final temperature. But organoleptically the quality of the fish of full-rigor type was considered as better than that of post-rigor type, and in the frozen fish with comparatively high final temperature, it is presumed that a percentage of glazing was less than that with comparatively low final temperature and the former was easily pressed out and deformed than the latter as it was stacked in cold strage.

4. Effect of Storage Temperature upon Quality of Frozen Fish.

Types of fish as above were frozen in an air-sharp type freezer by still air of temperature −22°C for 8 hours. The frozen samples without being glazed, were kept in cold rooms at −7, −14 and −21°C respectively for months. At the end of each definite period of storage, loss of weight of the frozen fish due to moisture evaporation was measured and then thawed in still air at +20°C. During thawing, not only values of drip, pH and protein *N*/total *N* in drip but also that of soluble total *N*/total *N*, soluble protein *N*/soluble total *N* and soluble heat coagulable *N*/soluble total *N* in muscle were measured on each samples. With the view that drip is exuded on thawing from frozen tissue due to the liberation of water from the muscle protein by means of the degeneration of protein during cold storage, these values of each nitrogen ratio were changing according to the change in drip value. The results are given in Table 8.

Any remarkable differences were not found from the drip value between the fishes of full-rigor and post-rigor types stored at −7, −14 and −21°C. But organoleptically the quality of the fish of full-rigor type was always considered as better than that of post-rigor type, and the lower the storage temperature the better the quality of fish was. It was observed that during cold storage the change in pH value of drip was somewhat noticeable with the full-rigor type, while the decrease in value of protein *N*/total *N* in drip was somewhat predominant with the post-rigor one. From these observations it may be accepted that the drip formation of both full-rigor and post-rigor types is mainly due to the liberation of water by the degeneration of its muscle protein. On the contrary, the differences of changes in values of soluble total *N*/total *N*, soluble protein *N*/soluble total *N* and soluble heat coagulable *N*/soluble total *N* in muscle were not so marked between the fishes of full-rigor and post-rigor types. Further, it

Table 9. Allowable period of storage at a given storage temperature of frozen lean fish as skip-jack.

Storage period m.	Storage temp. °C
up to 3	−10∼−15
6	−15∼−20
12	below −20

is clear that the lower the storage temperature, the fewer the changes are in these values except drip. On the other hand, loss of weight of the frozen whole round fish due to moisture evaporation proceeds with the period of storage, and

Table 10. Effect of air temperature in still air defrosting upon quality.

Air temp. °C	Defrosting time hrs.	Body temperature of fish °C						Dirp %		pH	
		full-rigor type			post-rigor type			full-rigor type	post-rigor type	full-rigor type	post-rigor type
		surface	intermediate	center	surface	intermediate	center				
	0	− 2.0	− 4.0	− 4.0	− 3.5	− 6.8	− 7.2	0.0	0.0	—	—
	1	0.0	− 3.0	− 3.0	− 1.5	− 5.0	− 6.2	0.0	0.0	—	—
	2	+ 2.0	− 2.0	− 2.8	0.0	− 4.0	− 4.0	0.0	0.0	—	—
	3	+ 2.0	− 2.0	− 2.5	0.0	− 3.0	− 3.5	0.0	0.0	—	—
	4	+ 2.0	− 2.0	− 2.0	0.0	− 2.0	− 3.0	0.0	0.0	—	—
+ 5	5	+ 3.0	− 1.5	− 2.0	0.0	− 1.5	− 2.5	0.0	0.0	—	—
	6	+ 4.0	− 1.5	− 1.9	0.0	− 1.5	− 2.1	0.0	0.0	—	—
	7	+ 4.0	− 1.0	− 1.5	0.0	− 1.5	− 2.0	0.0	0.0	—	—
	8	+ 4.5	− 1.0	− 1.0	0.0	− 1.5	− 1.5	0.0	0.0	—	—
	9	+ 5.0	− 1.0	− 1.0	0.0	− 1.5	− 1.5	0.0	0.0	—	—
	10	+ 5.0	− 1.0	− 1.0	0.0	− 1.5	− 1.5	0.0	0.0	—	—
	48	+ 5.0	+ 5.0	+ 5.0	+ 5.0	+ 5.0	+ 4.0	2.4	1.9	5.60	5.80
	0	− 3.0	− 4.5	− 4.5	− 3.0	− 4.5	− 4.8	0.0	0.0	—	—
	1	− 1.5	− 4.0	− 4.0	− 1.0	− 3.5	− 4.0	0.0	0.0	—	—
	2	0.0	− 3.0	− 3.0	0.0	− 3.0	− 3.0	0.0	0.0	—	—
	3	+ 2.0	− 2.8	− 3.0	+ 1.0	− 2.5	− 3.0	0.0	0.0	—	—
	4	+ 5.0	− 2.3	− 2.8	+ 3.0	− 2.0	− 2.8	0.0	0.0	—	—
	5	+ 5.0	− 2.0	− 2.5	+ 4.0	− 1.0	− 2.8	0.0	0.0	—	—
+10	6	+ 5.0	− 2.0	− 2.5	+ 5.0	− 1.0	− 2.7	0.0	0.0	—	—
	7	+ 5.0	− 2.0	− 2.2	+ 6.0	− 1.0	− 2.0	0.0	0.0	—	—
	8	+ 5.0	− 1.7	− 2.2	+ 9.0	− 1.0	− 1.0	0.0	0.0	—	—
	9	+ 6.0	− 1.0	− 2.0	+ 9.0	− 1.0	− 1.0	0.0	0.0	—	—
	10	+ 6.0	− 1.0	− 1.9	+ 9.5	− 1.0	− 1.0	0.8	0.8	5.40	5.70
	24	+ 7.0	+ 5.0	+ 5.0	+ 8.0	+ 8.0	+ 8.0	2.1	2.0	5.60	5.80
	0	− 4.0	− 8.0	− 9.0	− 7.5	− 8.0	− 9.5	0.0	0.0	—	—
	1	− 2.0	− 5.0	− 6.0	− 3.5	− 5.0	− 6.5	0.0	0.0	—	—
	2	0.0	− 3.0	− 4.0	0.0	− 3.0	− 4.0	0.0	0.0	—	—
	3	+ 1.0	− 2.5	− 3.0	+ 3.0	− 2.0	− 3.0	0.0	0.0	—	—
	4	+ 2.0	− 2.0	− 2.0	+ 5.0	− 1.0	− 2.0	0.8	0.4	5.60	5.80
+20	5	+ 8.0	0.0	− 1.0	+ 8.0	− 1.0	− 2.0	1.4	0.8	—	—
	6	+13.0	+ 6.5	+ 6.0	+10.0	− 1.0	− 2.0	1.8	1.1	5.40	5.80
	7	+16.0	+ 9.5	+ 8.5	+12.5	0.0	− 1.0	2.5	1.3	—	—
	8	+18.0	+14.0	+11.0	+15.0	+ 2.0	0.0	2.7	1.7	5.40	5.90
	24	+17.0	+17.0	+17.0	+17.0	+17.0	+17.0	3.2	2.2	5.70	6.05
	0	− 7.0	− 9.5	−10.2	− 8.5	− 9.0	− 9.2	0.0	0.0	—	—
	1	+15.5	− 6.0	− 7.0	+ 3.0	− 6.5	− 7.5	0.0	0.0	—	—
	2	+20.5	− 2.5	− 3.5	+ 5.0	− 3.0	− 3.5	1.2	1.4	5.50	5.80
	3	+25.5	+ 3.0	0.0	+15.0	− 2.0	− 2.0	1.5	1.5	—	—
	4	+27.5	+10.0	+ 5.5	+20.5	0.0	+ 0.5	1.8	1.6	5.40	5.80
+30	5	+30.0	+23.5	+11.0	+25.5	+15.0	+10.5	2.0	1.8	—	—
	6	+30.0	+29.5	+29.5	+30.0	+27.5	+27.5	2.3	2.1	5.40	5.90
	7	+30.0	+29.5	+29.5	+30.0	+29.5	+28.5	2.8	2.2	—	—
	8	+30.0	+30.0	+30.0	+30.0	+30.0	+30.0	3.2	2.3	5.40	6.00
	24	+27.5	+27.5	+27.5	+27.0	+27.0	+27.0	4.1	3.5	5.90	6.15

* The pH value of the sample of full-rigor type in unfrozen state is 5.85 in descending side and that of post-rigor type in unfrozen state is 5.70 in ascending side.

the higher is the storage temperature, the higher is the rate of loss of weight of the fish. Hence if we limit the loss of weight by moisture evaporation at 0.5~1.0% and take the deterioration of the fish during cold storage into consideration, the allowable period of storage at a given storage temperature may be provided as Table 9.

5. Effect of Defrosting Condition upon Quality of Frozen Fish.

a. Effect of Air Temperature in Still Air Defrosting upon Quality.

Types of fish as above were frozen in an air-sharp type freezer by still air of temperature −22°C for 8 hours. After freezing and cold storage at −15°C or so for about one month, the samples were thawed in still air at +5, +10, +20 and +30°C of temperature respectively for hours for measuring the values of drip and pH and observing the quality organoleptically. The results are given in Table 10.

Any remarkable differences were not observed from the drip value between the fishes of full-rigor and post-rigor types thawed at +5, +10, +20 and +30°C

Table 11. Effect of air velocity in moving air defrosting upon quality (at +20°C of air temperature)*.

Air velocity m/sec	Defrosting time hrs.	Body temperature of fish °C						Drip %	
		full-rigor type			post-rigor type			full-rigor type	post-rigor type
		surface	inter-mediate	center	surface	inter-mediate	center		
0	0	− 3.5	− 4.5	− 4.8	− 3.9	− 4.0	− 5.2	0.0	0.0
	1	0.0	− 2.5	− 3.5	− 2.5	− 3.1	− 3.5	0.0	0.0
	2	+ 1.0	− 1.0	− 1.0	0.0	− 2.1	− 2.5	0.0	0.0
	3	+ 3.5	− 1.0	− 1.0	+ 2.5	− 1.5	− 1.5	0.0	0.0
	4	+ 6.0	− 1.0	− 1.0	+ 5.5	− 1.0	− 1.5	0.2	0.0
	5	+ 7.5	0.0	− 1.0	+ 7.5	0.0	− 1.0	0.7	0.5
	6	+ 8.5	+ 1.0	0.0	+ 9.4	+ 2.5	− 0.5	1.0	0.8
	7	+12.5	+ 8.0	+ 5.0	+13.7	+ 8.5	0.0	1.4	1.2
	8	+15.5	+11.2	+ 8.5	+19.2	+12.0	+ 7.4	2.0	1.8
1	0	− 3.8	− 4.0	− 4.2	− 4.2	− 4.2	− 4.8	0.0	0.0
	1	0.0	− 1.0	− 1.5	+ 1.0	0.0	− 2.5	0.5	0.2
	2	+17.8	+ 6.3	+ 5.0	+10.0	+ 1.0	0.0	2.0	0.5
	3	+19.4	+13.0	+10.2	+15.0	+15.0	+ 5.7	2.3	1.4
	4	+19.4	+14.1	+12.2	+20.0	+15.2	+ 9.1	2.5	1.9
2.5	0	− 3.7	− 4.5	− 4.6	− 4.0	− 4.5	− 5.7	0.0	0.0
	1	0.0	− 1.0	− 2.5	− 1.0	− 1.0	− 2.5	1.2	0.7
	2	+ 8.2	+ 1.0	+ 2.4	+ 7.6	+ 2.1	+ 1.5	2.5	1.5
	3	+18.0	+18.0	+ 8.5	+15.2	+14.0	+ 7.2	2.7	1.8
	4	+19.5	+18.9	+12.4	+19.8	+19.8	+11.3	3.0	3.1
4	0	− 3.0	− 4.5	− 5.5	− 3.7	− 4.4	− 4.9	0.0	0.0
	1	+ 1.0	− 1.5	− 2.5	+ 5.7	− 1.5	− 1.5	0.5	0.3
	2	+11.3	0.0	0.0	+11.5	+11.2	+ 1.5	1.0	1.2
	3	+18.7	+15.1	+ 9.5	+18.5	+16.7	+ 8.2	2.1	1.9
	4	+20.0	+20.0	+15.7	+20.0	+16.7	+16.5	3.0	2.7

* The pH value of the sample of full-rigor type in unfrozen state is 5.85 in descending side and that of post-rigor type in unfrozen state is 5.70 in ascending side.

of air temperature. But organoleptically, the quality of the fish of full-rigor type was considered as better than that of post-rigor type, and the lower the air temperature for defrosting of the frozen fish, the better the quality of defrosted fish was. But the defrosting time of the samples thawed at +5 and +10°C of air temperature are about 48~16 hours while that of +20 and +30°C of air temperature are about 8~6 hours. From these defrosting time, the former is so-called slow-defrosting and the latter quick-defrosting. It can be pointed out, therefore, that the slow-defrosting gives to some extent good quality of defrosted fish than the quick-defrosting. As the quality of sample thawed at +5°C of air temperature was scarcely distinguished from that of +10°C of air temperature, recommended air temperature in still air defrosting is practically +10°C or so.

b. Effect of Air Velocity in Moving Air Defrosting upon Quality.

Types of fish as above were frozen in an air-sharp type freezer by still air of temperature −22°C for 8 hours. After freezing and cold storage at −15°C or so for about one month, the samples were thawed in moving air in 0, 1, 2.5 and 4 m/sec of velocity and +20°C of temperature respectively for hours for

Table 12. Effect of water temperature in still water defrosting upon quality.

Water temp. °C	Defrosting time hrs.	Body temperature of fish °C						Weight loss %	
		full-rigor type			post-rigor type			full-rigor type	post-rigor type
		surface	intermediate	center	surface	intermediate	center		
+ 5	0	—	− 6.2	− 7.5	—	− 7.4	− 8.1	0.0	0.0
	1	—	− 5.0	− 6.0	—	− 6.2	− 7.1	0.0	0.0
	2	—	− 3.0	− 3.7	—	− 2.5	− 4.0	0.0	0.0
	3	—	− 2.0	− 2.5	—	− 2.5	− 2.5	0.0	0.0
	4	—	− 1.0	− 1.5	—	− 1.0	− 1.5	0.0	0.0
	5	—	− 1.0	− 1.0	—	− 1.0	− 1.0	0.0	0.0
	6	—	+ 1.0	0.0	—	0.0	− 1.0	0.4	0.6
	7	—	+ 2.5	+ 1.0	—	+ 2.0	0.0	1.1	1.2
	8	—	+ 5.0	+ 3.7	—	+ 4.0	+ 2.5	1.5	1.7
	24	—	+ 5.0	+ 5.0	—	+ 4.5	+ 4.5	1.9	−1.8
+10	0	—	− 7.5	− 8.5	—	− 6.4	− 7.4	0.0	0.0
	1	—	− 4.3	− 4.5	—	− 3.2	− 4.7	0.0	0.0
	2	—	− 1.5	− 2.5	—	− 1.0	− 2.0	0.0	0.0
	3	—	− 1.0	− 1.5	—	− 1.0	− 1.0	0.0	0.0
	4	—	+ 3.3	0.0	—	+ 4.2	0.0	0.7	0.9
	5	—	+ 6.5	+ 4.5	—	+ 8.5	+ 2.5	1.4	1.3
	6	—	+ 9.5	+ 9.0	—	+ 9.0	+ 7.5	1.8	1.6
	24	—	+ 9.5	+ 9.5	—	+ 9.0	+ 9.0	1.9	−2.4
+20	0	—	− 7.0	− 7.8	—	− 5.4	− 6.3	0.0	0.0
	1	—	− 4.5	− 5.4	—	− 3.5	− 3.5	0.0	0.0
	2	—	− 1.0	− 1.5	—	− 1.0	− 1.0	0.0	0.0
	3	—	+ 4.2	0.0	—	+ 3.5	+ 1.0	0.7	0.9
	4	—	+14.5	+ 8.2	—	+15.5	+10.2	1.6	1.6
	24	—	+18.4	+18.4	—	+20.0	+20.0	2.1	−1.9
+30	0	—	− 6.4	− 7.4	—	− 5.4	− 6.7	0.0	0.0
	1	—	+ 2.1	0.0	—	+ 3.5	0.0	0.7	0.8
	2	—	+19.1	+11.0	—	+22.3	+14.7	2.1	1.9
	24	—	+27.5	+27.5	—	+29.0	+29.0	2.5	−3.7

measuring the drip value and observing the quality organoleptically. The results are given in Table 11.

Any marked differences were not found from the drip value between the fishes of full-rigor and post-rigor types thawed in 0, 1, 2.5 and 4 m/sec of air velocity. But organoleptically the quality of the fish of full-rigor type was considered as better than that of post-rigor type though any clear differences were not detected on their quality by means of discrepancy of the air velocity. While it is a fact that the more rapid the air velocity is, the quicker the frozen fish is defrosted. In air defrosting, however, it is better to use the still air defrosting at temperature of +10°C or so than the moving air one, because a loss of weight of the fish due to moisture evaporation during deforsting is much occurred in moving air defrosting.

c. Effect of Water Temperature in still Water Defrosting upon Quality.

Types of fish as above were frozen in an air-sharp type freezer by still air of temperature −22°C for 8 hours. After freezing and cold storage at −15°C or so for about one month, the samples were thawed in still water at +5, +10, +20 and +30°C of temperature respectively for hours for measuring the value of weight loss (as drip was flown away in water) and observing the quality organoleptically. The results are given in Table 12.

Any remarkable differences were not observed from the value of weight loss between the fishes of full-rigor and post-rigor types thawed at +5, +10, +20 and +30°C of water temperature. But organoleptically, the quality of the fish of full-rigor type was considered as better than that of post-rigor type, and the lower the water temperature for defrosting of the frozen fish, the better the quality of defrosted fish was. Those samples defrosted at lower temperature of

Table 13. Effect of water velocity in moving water defrosting upon quality (at +20°C of water temperature).

Water velocity m/sec	Defrosting time hrs.	Body temperature of fish °C						Weight loss %	
		full-rigor type			post-rigor type			full-rigor type	post-rigor type
		surface	intermediate	center	surface	intermediate	center		
0.00	0	—	− 8.0	− 8.0	—	− 4.9	− 6.9	0.0	0.0
	1	—	− 5.0	− 6.0	—	− 2.0	− 4.0	0.0	0.0
	2	—	0.0	− 1.0	—	0.0	− 1.0	0.0	0.0
	3	—	+ 6.0	0.0	—	+ 7.0	+ 1.0	0.6	0.4
	4	—	+10.0	+ 4.0	—	+ 8.2	+ 2.5	1.5	1.2
0.09	0	—	− 5.4	− 7.0	—	− 4.5	− 5.3	0.0	0.0
	1	—	+ 6.2	0.0	—	+ 4.3	+ 0.5	1.0	1.0
	2	—	+10.0	+ 7.0	—	+12.2	+ 8.4	1.9	1.7
0.20	0	—	− 4.8	− 5.6	—	− 5.2	− 5.2	0.0	0.0
	1	—	+ 6.2	+ 1.0	—	+ 5.5	+ 1.5	1.4	1.2
	2	—	+12.5	+11.0	—	+ 8.2	+ 4.4	1.6	1.3
0.36	0	—	− 4.2	− 6.2	—	− 5.4	− 6.2	0.0	0.0
	1	—	+ 7.2	+ 2.0	—	+ 5.5	0.0	1.2	0.8
	2	—	+15.5	+12.3	—	+11.2	+ 8.9	1.8	1.2

water are quite excellent as well as those defrosted at lower temperature of air in quality. But the defrosting time of the samples thawed at +5 and +10°C of water temperature is about 8~6 hours while that of +20 and +30°C of water temperature is about 4~2 hours. From these defrosting time, the former is slow-defrosting and the latter quick-defrosting. It may be pointed out, therefore, that the slow-defrosting gives to some extent good quality of defrosted fish than the quick-defrosting. As the quality of sample thawed at +5°C of water temperature was scarcely distinguished from that of +10°C of water temperature, recommended water temperature in still water defrosting is practically +10°C or so.

d. Effect of Water Velocity in Moving Water Defrosting upon Quality.

Types of fish as above were frozen in an air-sharp type freezer by still air of temperature −22°C for 8 hours. After freezing and cold storage at −15°C or so for about one month, the samples were thawed in moving water in 0.00, 0.09, 0.20 and 0.36 m/sec of velocity and +20°C of temperature respectively for hours for measuring the value of weight loss (as drip was flown away in water also) and observing the quality organoleptically. The results are given in Table 13.

Any marked differences were not found from the value of weight loss

Table 14. Effect of salt concentration in still NaCl brine defrosting upon quality (at +20°C of brine temperature).

NaCl concentration %	Defrosting time hrs.	Body temperature of fish °C						Weight loss %	
		full-rigor type			post-rigor type			full-rigor type	post-rigor type
		surface	intermediate	center	surface	intermediate	center		
0	0	—	− 4.2	− 5.5	—	− 3.7	− 4.7	0.0	0.0
	1	—	− 1.0	− 1.5	—	− 1.5	− 1.5	0.5	0.0
	2	—	+ 3.2	0.0	—	+ 2.9	− 0.5	0.8	0.0
	3	—	+10.5	+ 1.0	—	+ 8.5	0.0	1.0	0.8
	4	—	+15.0	+14.0	—	+12.5	+11.0	1.2	1.6
	24	—	+19.5	+19.5	—	+19.5	+19.5	2.3	−2.0
5	0	—	− 4.4	− 5.5	—	− 4.1	− 4.1	0.0	0.0
	1	—	0.0	− 2.5	—	+ 1.0	− 1.5	0.0	0.0
	2	—	+ 3.0	− 1.0	—	+ 4.4	+ 1.2	0.0	0.1
	3	—	+ 8.5	+ 5.2	—	+10.1	+ 7.4	0.3	0.3
	4	—	+13.2	+10.2	—	+14.8	+13.2	0.7	0.5
	24	—	+17.5	+17.5	—	+16.0	+16.0	1.5	0.9
15	0	—	− 5.1	− 6.1	—	− 4.3	− 5.2	0.0	0.0
	1	—	− 1.5	− 2.5	—	0.0	− 2.5	0.0	0.0
	2	—	+ 1.8	− 0.5	—	+ 3.1	+ 0.5	0.0	0.5
	3	—	+ 6.5	+ 4.2	—	+ 7.5	+ 3.5	0.2	0.5
	4	—	+12.1	+ 8.7	—	+12.2	+ 6.6	0.5	0.6
	24	—	+16.2	+16.2	—	+16.2	+16.2	1.5	0.7
25	0	—	− 3.2	− 4.8	—	− 4.2	− 5.6	0.0	0.0
	1	—	− 1.0	− 2.5	—	− 1.0	− 3.0	0.0	0.0
	2	—	+ 2.5	0.0	—	+ 3.1	0.0	0.0	0.0
	3	—	+ 7.2	+ 3.5	—	+11.0	+ 5.0	0.0	0.0
	4	—	+13.3	+ 7.2	—	+12.5	+ 8.4	0.4	0.5
	24	—	+16.5	+16.5	—	+16.0	+16.0	1.1	0.7

between the fishes of full-rigor and post-rigor types thawed in 0.00, 0.09, 0.20 and 0.36 m/sec of water velocity. But organoleptically the quality of the fish of full-rigor type was considered as better than that of post-rigor type though any clear differences were not detected on their quality by means of discrepancy of the water velocity. While it is a fact that the more rapid the water velocity is, the quicker the frozen fish is defrosted. In water defrosting, therefore, it is better to use the moving water defrosting at speed of 0.16 m/sec or so than the still water one, because the quality of fish is considered as not being affected by the water velocity.

e. Effect of Salt Concentration in Still NaCl Brine Defrosting upon Quality.

Types of fish as above were frozen in an air-shape type freezer by still air of temperature −22°C for 8 hours. After freezing and cold storage at −15°C or so for about one month, the samples were thawed in NaCl brine at 0, 5, 15 and 25 % of concentration and +20°C of temperature respectively for hours for measuring the value of weight loss (as drip was flown away in brine) and observing the quality organoleptically. The results are given in Table 14.

Any remarkable differences were not observed from the value of weight loss between the fishes of full-rigor and post-rigor types thawed at 0, 5, 15 and 25 % of NaCl concentration. Organoleptically the quality of all fish was not so good though the quality of the fish of full-rigor type was to same extent considered as better than that of post-rigor type. Therefore this defrosting process is not good for the means of thawing of frozen fish.

f. Effect of Ice Defrosting upon Quality.

Types of fish as above were frozen in an air-sharp type freezer by still air of temperature −22°C for 8 hours. After freezing and cold storage at −15°C or so for about one month, the samples were thawed by crushed ice in cold room of temperature 0°C for hours for measuring the value of weight loss (as drip was flown away in crushed ice) and observing the quality organoleptically. The results are given in Table 15.

Table 15. Effect of ice defrosting upon quality.

Defrosting time hrs.	Body temperature of fish °C						Weight loss %	
	full-rigor type			post-rigor type			full-rigor type	post-rigor type
	surface	intermediate	center	surface	intermediate	center		
0	−6.5	−7.5	−8.0	−6.0	−6.2	−7.5	0.0	0.0
1	−4.5	−6.5	−7.0	−4.5	−5.4	−6.5	0.0	0.0
2	−3.5	−5.2	−5.7	−4.0	−4.8	−5.4	0.0	0.0
3	−2.5	−4.0	−4.0	−3.0	−3.5	−4.5	0.0	0.0
4	−2.0	−3.0	−3.5	−2.0	−2.5	−3.5	0.0	0.0
5	−1.0	−2.5	−3.0	−1.5	−2.5	−2.5	0.0	0.0
6	−1.0	−2.5	−2.7	−1.5	−2.0	−2.5	0.0	0.0
7	−1.0	−2.5	−2.6	−1.5	−2.0	−2.5	0.0	0.0
8	−1.0	−2.2	−2.6	−1.5	−2.0	−2.2	0.0	0.0
9	−1.0	−2.0	−2.5	−1.0	−2.0	−2.0	0.0	0.0
10	−1.0	−2.0	−2.5	−1.0	−2.0	−2.0	0.0	0.0
24	−1.0	−1.0	−1.0	−1.0	−1.0	−1.0	0.0	0.0

The value of weight loss was none in all samples and the quality of all fish inspected organoleptically was quite good. From the results of these observations this defrosting process is quite excellent for the means of thawing of frozen fish of both full-rigor and post-rigor types. But it is presumed that this defrosting process is not practical because its defrosting time is too long.

Conclusion

To obtain the frozen whole round skip-jack of superior quality organoleptically, it is practically recommended to select the raw materials as fresh as possible (like as full-rigor type), freeze quickly with the low initial and final temperature as the fish was taken into and out of freezer if possible, store at temperature kept as low as possible and defrost by still air of temperature +10°C or so or moving water of temperature +10°C or so and velocity 0.16 m/sec or so. From the organoleptical standpoint, it is also recommended that the thawing of frozen fish should be ceased when the temperature of the central part of fish was attained at −1°C (freezing or melting point of fish) and its frozen tissue was partially thawed.

The amount of drip exuded from the frozen fish is seldom affected on the freshness of fish (full-rigor or post-rigor types), the form of fish muscle (whole round fish or fish-fillet), freezing conditions (initial and final temperature and freezing rate of fish), storage conditions (mainly storage temperature) and defrosting conditions (air defrosting or water defrosting, temperature and velocity of thawing medium etc.). Therefore, the drip value cannot be adopted as an index to inspection of the quality of the frozen fish.

Though the storage temperature of such frozen lean fish as the frozen whole round skip-jack should be kept as low as possible, as a practical standard, allowable storage period at a given storage temperature may be taken as follows, up to 3 month's storage at −10∼−15°C, 6 month's at −15∼−20°C and 12 month's at below −20°C.

Acknowledgement

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INFLUENCE OF GAMMA IRRADIATION ON NUTRITIVE CONSTITUENTS OF FOODS
EFFECTS OF GAMMA IRRADIATION ON FOLIC ACID. PART I.

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Introduction

On the preservation of foods by gamma irradiation, it has been shown that the nutritive constituents of foods, especially vitamins undergo chemical and organoleptic changes. Their changes of folic acid exposed to irradiation of gamma-ray, however, are not studied in detail except the studies described partially in the reports of Elliott *et al.*[1], Alexander *et al.*[2], and others[3].

With the purpose of the foundamental studies of the effects of gamma irradiation on folic acid, the authors treated the alkaline solution of folic acid with gamma-ray from cobalt 60 (Co^{60}) source and studied as follows:

(A) Relation between the concentration of folic acid and the irradiation doses.

(B) Protecting effects of stabilizers added to the folic acid solution. In this experiment, DL-methionine and *p*-aminobenzoic acid were added as stabilizers. Rauen *et al.*[5] reported that *p*-aminobenzoic acid (one of the components of folic acid) is an effective stabilizer, and the more effective result was obtained by Kuwada *et al.*[6] when DL-methionine is added to the folic acid solution on sunlight exposure.

(C) Sunlight exposure on folic acid was carried out as compared with the gamma irradiation in this study. As to the sunlight exposure, Mitchell and Williams[4], and others[8][9][10] reported in detail.

The authors studied on the above mentioned subjects by the polarographic, spectrophotometric, and paper chromatographic methods.

Experimental

Method of sampling and irradiation.

(A) To research on the relation between the concentration of folic acid and irradiation doses, 10, 50 and 100 mg% of folic acid in 0.05 N sodium hydroxide solutions were prepared (the purity of folic acid used in this experiment was 92.2%).

Each of 20 ml. of the solution was filled into colorless glass ampoule and irradiated at $0.6\sim3.5\times10^5$ r. of gamma-ray from 100 curies of Co^{60} source, the details were shown in Table 1.

Non-irradiated solution used as control was kept in the same condition.

(B) To research the effectiveness of stabilizers in protecting folic acid from

Table 1. Irradiation doses of gamma-ray from Co^{60}.

(A) Irradiation on various concentration of folic acid (100, 50 and 10 mg%).

Sample No.	Total doses (roentogen)	Dose rates (r/hr)	Irradiation hours (hr)
1	3.5×10^5	7,000	50 continuously
2	2.2×10^5	4,440	50 〃
3	1.5×10^5	2,970	50 〃
4	1.2×10^5	2,400	50 〃
5	0.6×10^5	1,260	50 〃

(B) Irradiation on the solution of folic acid containing stabilizers.

Sample No.	Total doses (roentogen)	Dose rates (r/hr)	Irradiation hours (hr)
1	3.0×10^5	7,000	43 continuously
2	2.0×10^5	4,440	43 〃
3	1.0×10^5	2,400	43 〃

the action of gamma irradiation, DL-methionine or *p*-aminobenzoic acid was added as to be in concentration of 50 mg% to each folic acid solution (in this case 50 mg% of folic acid solution in 0.05 N sodium hydroxide was used). Then these samples were filled into colorless glass ampoules as mentioned (A) and irradiated as shown in Table 1.

(C) Sunlight exposure on folic acid was carried out in the weather of November for 3 hours.

Measurements.

i. Organoleptic tests.

ii. Polarographic test.

The solutions of 10 ml. of samples were neutralized with 0.5 N HCl and filled up to 25 ml. with McIlvaine buffer solution (pH=7.0). Then the effects of gamma-ray were estimated by the depreciation of wave heights on the polarograms which were recorded with an automatic pen-recording apparatus.

iii. Spectrophotometric test.

It was found that the diluted solutions (to 50 ml.) of 1 ml. of samples were satisfactorily estimated spectrophotometrically. All measurements of light absorption were done on a Beckman Model DU spectrophotometer.

iv. Chromatographic test.

One-dimensional ascending procedure was used. The solutions of 0.05～0.01 ml. of samples were pipetted on a filter paper (Toyo filter paper No. 2), then they were developed with the solvent of water, *n*-butanol, and acetic acid mixture (5 : 4 : 1) for 15 hours in the dark at a room temperature (23±1°C). The separated spots were detected as follows:

(a) The absorbed and fluorescent spots were ascertained under the mercury lamp.

(b) Colored spots of amino acids such as DL-methionine used as stabilizer

were observed by spraying ninhydrin when the paper was heated at 80°C for 5 minutes.

(c) *p*-Aminobenzoic acid and *p*-aminobenzoylglutamic acid were detected (if enough quantity present) by the reaction with *p*-dimethylaminobenzaldehyde.

Results and discussion

I. *Organoleptic observation and pH value of irradiated samples.*

Color: Light greenish yellow color of folic acid solution in 0.05 N sodium hydroxide was slightly changed to brownish yellow in conformity with the irradiation doses, and the color intensity was increased when the concentration of folic acid is higher. The color change was not so great when DL-methonine or *p*-aminobenzoic acid was added in the folic acid solution.

Precipitation: Formation of precipitation was not observed in this experiment.

Odor: On the only case of DL-methionine added to samples, faintly mercaptan-like odor was detected in gamma irradiated solution. It was assumed that this odor was caused by the sulfur in the molecule of methionine.

pH value: pH values of samples were not almost influenced by gamma irradiation and sunlight exposure as shown in Table 2.

Table 2. pH values of folic acid solutions by gamma irradiation and sunlight exposure.

(A) Influence of various concentration of folic acid.

Conc. of folic acid (mg%)	Non-irradiated control	Irradiation doses (roentogen)					Sunlight exposure 3 hrs.
		0.6×10^5	1.2×10^5	1.5×10^5	2.2×10^5	3.5×10^5	
100	11.42	11.41	11.44	11.41	11.44	11.42	11.42
50	11.46	11.44	11.42	11.44	11.41	11.40	11.41
10	11.41	11.41	11.42	11.40	11.42	11.43	11.41

(B) Influence of addition of stabilizers to folic acid (50 mg%).

Stabilizers added to folic acid	Non-irradiated control	Irradiation doses (roentogen)			Sunlight exposure 3 hrs.
		1.0×10^5	2.0×10^5	3.0×10^5	
Stabilizers not added	12.00	11.61	11.72	11.64	11.96
DL-Methionine added	11.54	11.71	11.69	11.54	11.98
p-Aminobenzoic acid added	11.71	11.72	11.76	11.68	11.93

II. *Polarographic studies of folic acid deteriorated by gamma irradiation and sunlight exposure.*

Polarograms of folic acid deteriorated by gamma irradiation and sunlight exposure were shown in Fig. 1 and that of protecting effects of DL-methionine and *p*-aminobenzoic acid were shown in Fig. 2.

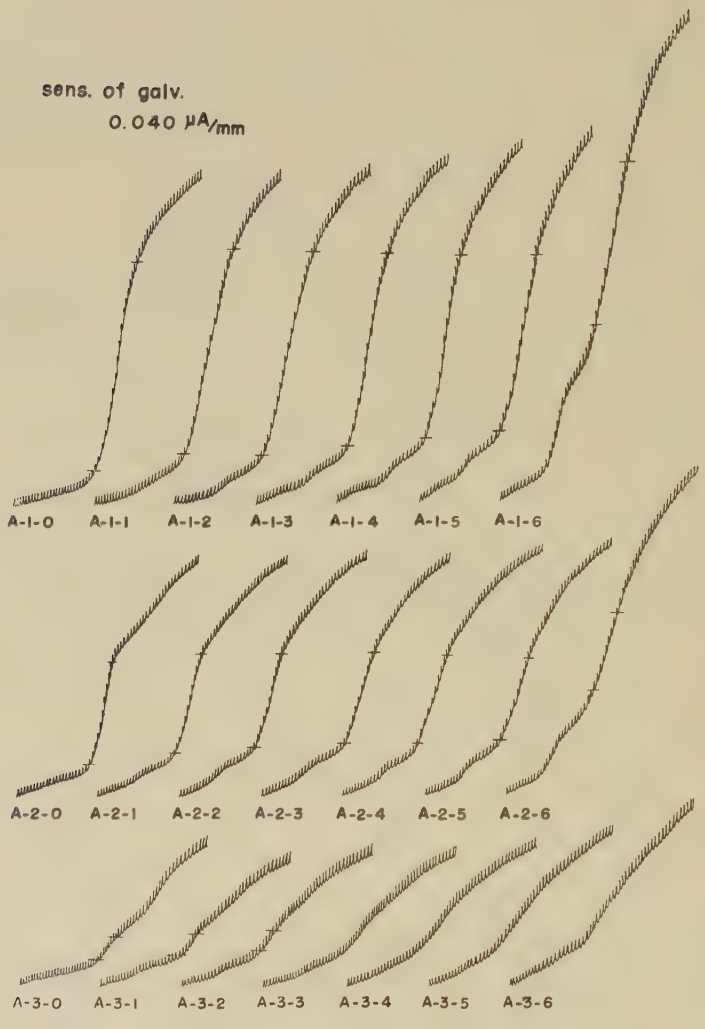

Fig. 1. Polarograms of each different concentration of folic acid solution (100, 50 and 10 mg %) irradiated by gamma-ray.

A-1 series, 100 mg%; A-2 series, 50 mg%; A-3 series, 10 mg%.

0. Non-irradiated control; 1. 0.6×10^5 r.; 2. 1.2×10^5 r.; 3. 1.5×10^5 r 4. 2.2×10^5 r.; 5. 3.5×10^5 r.; 6. Sunlight exposure for 3 hrs.

As shown in Figs. 1 and 2, or Table 3, non-irradiated control of folic acid solution produced a reduction wave at $-0.75\sim-0.78$ V., but two reduction waves at $-0.55\sim-0.58$ V. and $-0.75\sim-0.78$ V. were obtained by gamma irradiation and sunlight exposure. As the reduction wave at $-0.75\sim-0.78$V. originate from folic acid, then that of $-0.55\sim-0.58$V. is caused by unknown substance after gamma irradiation and sunlight exposure. As to this unknown wave at $-0.55\sim-0.58$V. further invetigation is required and its result will be reported in the near future. The

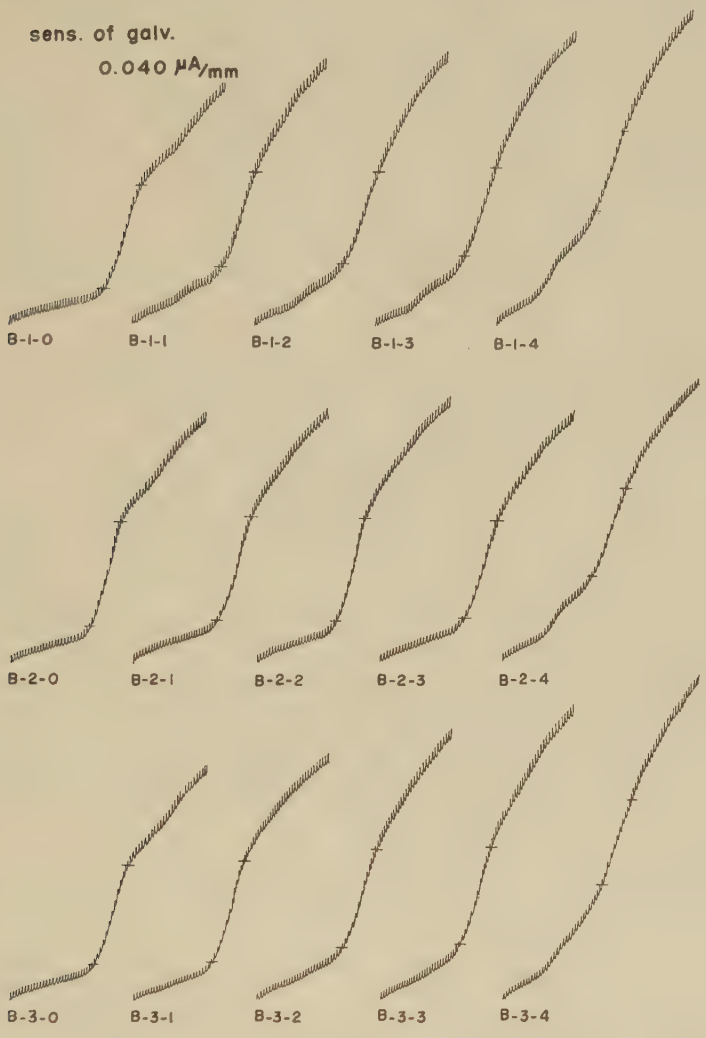

Fig. 2. Polarograms of folic acid (50 mg%) containing stabilizers (DL-methionine and *p*-aminobenzoic acid) irradiated by gamma-ray.

B–1 series, folic acid (50 mg%); B–2 series, folic acid (50 mg%)+DL-methionine (50 mg%); B–3 series, folic acid (50 mg%)+*p*-aminobenzoic acid (50 mg%).

0. Non-irradiated control; 1. 1.0×10^5 r.; 2. 2.0×10^5 r.; 3. 3.0×10^5 r.; 4. Sunlight exposure for 3 hrs.

decreasing behaviour of reduction waves were proportional to the irradiation doses, and its degree was greater in the case of sunlight exposure than that of gamma irradiation in this experiment. As there is a linear relation between the concentrations of folic acid and their polarographic reduction wave heights,[7)11)12)13)] the deterioration of folic acid is determined by the wave heights shown in Table 4.

As shown in Fig. 3 or Table 4, when the irradiation dose is obtained at the same

Table 3. Half wave potentials (π 1/2 vs S.C.E.) of folic acid caused by gamma irradiation and sunlight exposure.

Irradiation doses (roentogen) \ Stabilizers	Stabilizers not added	DL-Methionine added	*p*-Aminobenzoic acid added
	Volt	Volt	Volt
Non-irradiated control	−0.784	−0.750	−0.778
1.0×10^5	−0.793 (−0.57)	−0.778 —	−0.750 —
2.0×10^5	−0.787 (−0.55)	−0.761 —	−0.778 —
3.0×10^5	−0.774 (−0.55)	−0.784 —	−0.776 —
Sunlight exposure 3 hrs.	−0.791 (−0.57)	−0.784 (−0.57)	? (−0.58)

Note: Half wave potentials of small wave for unknown products are shown on figure in parentheses.

Table 4. Wave heights (H) and residual rates (R) of folic acid by gamma irradiation and sunlight exposure.

(A) Difference of depreciation by the concentration of folic acid.

Irradiation doses (roentogen) \ Conc. of folic acid	100 mg%		50 mg%		10 mg%	
	H	R	H	R	H	R
	mm	%	mm	%	mm	%
Non-irradiated control	69.2	100	34.0	100	7.5	100
0.6×10^5	67.8	98.1	32.3	95.0	6.9	92.0
1.2×10^5	66.8	96.6	31.7	93.2	6.2	82.9
1.5×10^5	63.6	92.0	29.8	87.6	—	—
2.2×10^5	61.1	88.5	29.4	86.5	—	—
3.5×10^5	58.2	84.1	27.0	79.5	—	—
Sunlight exposure 3 hrs.	54.8	78.5	25.1	73.8	—	—

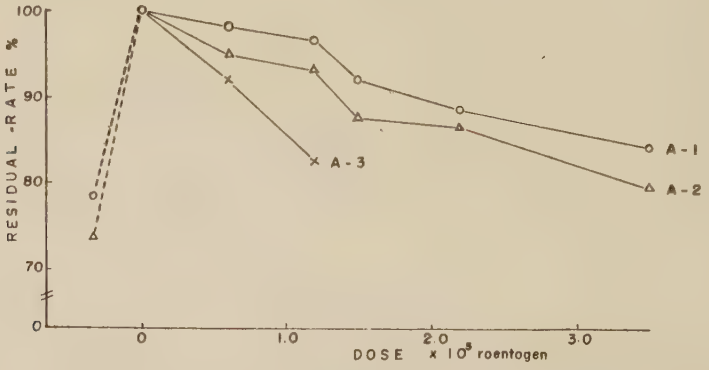

Fig. 3. Residual rates of each different concentration of folic acid irradiated by gamma-ray (calculated by the wave heights shown in Table 4).
A-1, 100 mg% folic acid; A-2, 50 mg% folic acid; A-3, 10 mg% folic acid; Dotted lines, sunlight exposure for 3 hrs.

(B) Effects of stabilizers to folic acid solution (conc. of folic acid, 50 mg%).

Stabilizers / Irradiation doses (roentogen)	Stabilizers not added		DL-Methionine added		*p*-Aminobenzoic acid added	
	H	R	H	R	H	R
	mm	%	mm	%	mm	%
Non-irradiated control	33.8	100	33.8	100	33.1	100
1.0×10^5	31.6	93.5	33.7	99.7	32.8	99.1
2.0×10^5	30.7	90.8	33.2	98.2	31.7	95.7
3.0×10^5	28.8	85.2	32.0	94.6	31.0	93.6
Sunlight exposure 3 hrs.	26.7	79.0	28.5	84.4	27.3	82.5

degree, lower concentration of folic acid is more labile than higher concentration as already reported on the irradiated vitamin C[14], namely at the dose of 3.5×10^5 r. the deterioration of folic acid was about 16% in 100 mg% solution of folic acid, but about 20% in 50 mg% solution, and in the case of sunlight exposure about 21% in the former and about 26% in the latter.

As shown in Fig. 2, when the stabilizers were added to the folic acid solution, the characteristic small wave at $-0.55\sim-0.58$ V. was almost disappeared except at the dose of 3.5×10^5 r. on folic acid added with *p*-aminobenzoic acid. However, though the stabilizers were added, two waves were obtained on the sunlight exposure for 3 hours. As shown in Fig 4 or Table 4, DL-methionine was more effective than *p*-aminobenzoic acid in either gamma irradiation as well as sunlight exposure. In this polarographic studies, unknown waves have the same potential ($-0.55\sim-0.58$ V.) in both cases of gamma irradiation and sunlight exposure, therefore it will be presumed that folic acid was partially decomposed into the dentical substance by gamma-ray or sunlight.

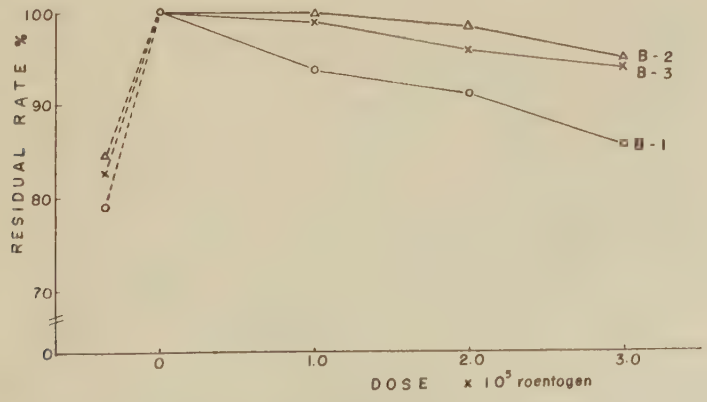

Fig. 4. Residual rates of folic acid (50 mg%) containing stabilizers irradiated by gamma-ray (calculated by the wave heights shown in Table 4).

B-1, folic acid (50 mg%); B-2, folic acid (50 mg%)+DL-methionine (50 mg%); B-3, folic acid (50 mg%)+*p*-aminobenzoic acid (50 mg%); Dotted lines, sunlight exposure for 3 hrs.

III. *Spectrophotometric studies.*

Figs. 5, 6 and 7 show the ultraviolet spectral absorption of folic acid in all cases in this experiment. The absorption maxima of pure folic acid in 0.05 N sodium hydroxide were observed at 255, 285 and 365 mμ. According to the report of Kuwada *et al.*[8)9)], the absorption maxima at 255 and 286 mμ are characteristic for

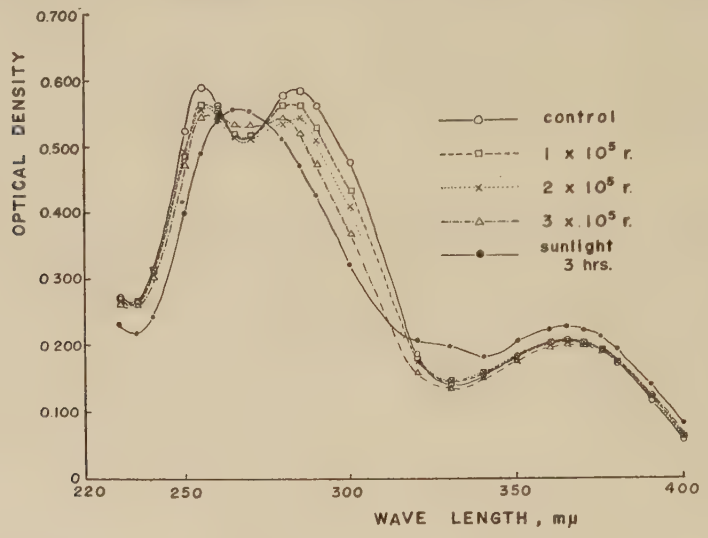

Fig. 5. Ultraviolet absorption spectra of folic acid in 0.05 N NaOH. All were measured with the solutions containing 1 ml. of folic acid (50 mg%) per 5 ml. in 0.05 N NaOH.

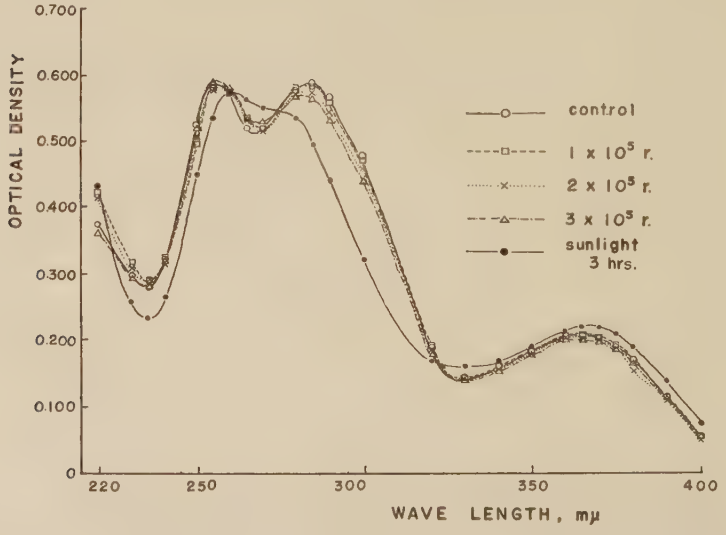

Fig. 6. Ultraviolet absorption spectra of folic acid (50 mg%) containing DL-methionine as stabilizer. All were measured as shown in Fig. 5.

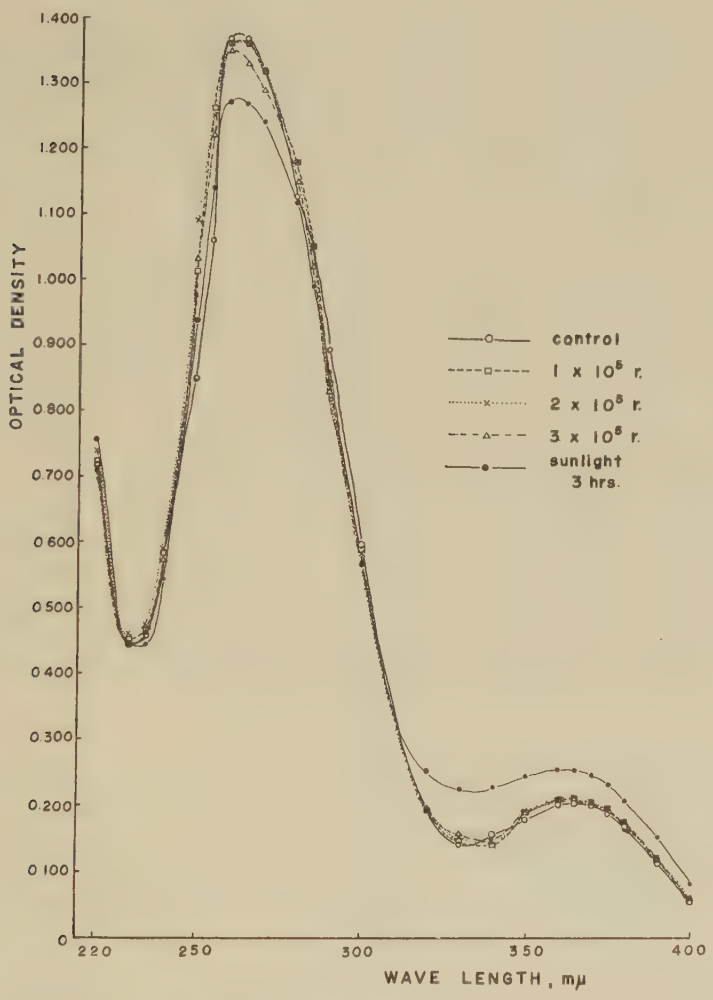

Fig. 7. Ultraviolet absorption spectra of folic acid (50 mg%) containing *p*-aminobenzoic acid as stabilizer. All were measured as shown in Fig. 5.

pure folic acid, and at 370 mμ is not always characteristic for folic acid but obtainable by pteridines. Therefore, in this study the absorption maxima at 255, 285 and 365 mμ are due to folic acid and its decomposition product that has pteridines. Now, the wave length of absorption maximum at 370 mμ and optical density of gamma irradiated samples were almost unaltered, but slight change was appeared at 255 and 285 mμ.

In high doses of gamma irradiation two peaks of absorption were lower than that of non-irradiated control, and having a tendency to become one peak. This tendency was most intense in the sunlight exposure and ultimately became one peak which has absorption maximum at 265 mμ. It has been presumed that the cleavage of pteridines was not caused by the gamma irradiation in this experiment.

As to the absorption maxima of folic acid containing DL-methionine as stabilizer was not so much influenced as compared with the non-irradiated solution, then it is assumed that DL-methionine is a protective agent against gamma irradiation. On the other hand, in the case of *p*-aminobenzoic acid as stabilizer, the absorption maxima at 255 and 285 mμ were not observed because the absorption of *p*-aminobenzoic acid itself is present at 265 mμ.

IV. *Chromatographic studies.*

According to the polarographic and spectrophotometric methods, the decomposition product of folic acid by gamma irradiation was identical with substance that formed by sunlight exposure. Then the paper chromatographic studies were carried out as further investigation. In this chromatographic studies, the result was shown in Fig. 8. By the irradiation of folic acid, several intense

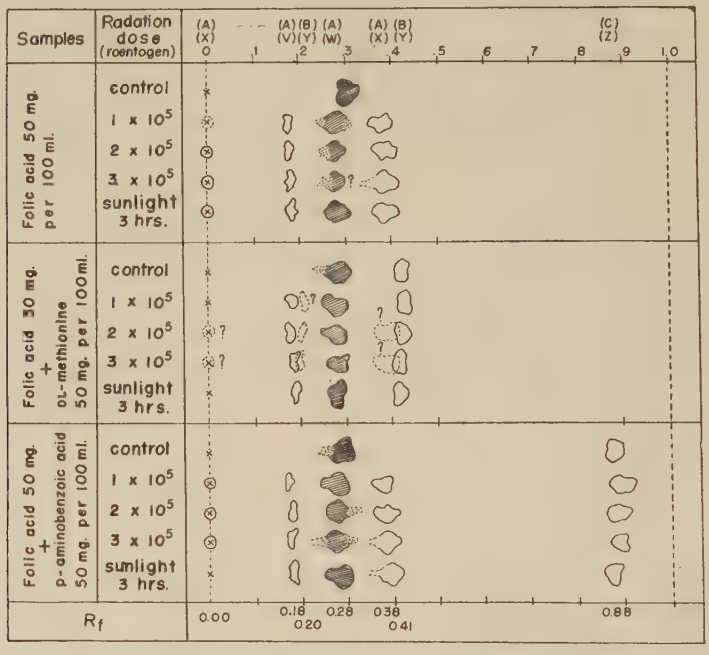

Fig. 8. Paper chromatograms of folic acid containing stabilizers, DL-methionine and *p*-aminobenzoic acid.

Development: one-dimensional ascending procedure on the Toyo filter paper No. 2 for 15 hrs. at 23±1°C. in the dark.

Solvent: water, *n*-butanol, and acetic acid mixture (5 : 4 : 1).

Detection: (A) absorbed and fluorescent spots under the mercury lamp, blue (V), blue violet (X), black absorbed (W).

(B) ninhydrin colored spot, redish violet (Y).

(C) *p*-dimethylaminobenzaldehyde colored spot, yellow (Z).

fluorescent spots were obtained on the chromatograms. The blue-violet fluorescent spot was observed at the Rf value of 0.00. It seems to be a spot of unknown

product. At the Rf value of 0.38, the same fluorescent spot was obtained and identified as 6-methylpteridine (2-amino-4-hydroxy-6-methylpteridine) reported by Kuwada *et al.*[4)6)8)9)] Moreover, the blue fluorescent spot at the Rf value of 0.18 was assumed to be that of pteridine-6-carboxylic acid (2-amino-4-hydroxy-pteridine-6-carboxylic acid).

At the Rf value of 0.28, the black-absorbed spot was assumed to be folic acid, because this was ascertained in all irradiated samples and markedly in non-irradiated sample of pure folic acid. As to DL-methionine added as stabilizer, violet colors were produced by spraying ninhydrin at the Rf values of 0.41 and 0.20. The former shows the Rf value of the separated DL-methionine itself, the latter shows that of unknown product.

In all samples except the addition of DL-methionine the positive reaction with ninhydrin was not confirmed on the paper chromatograms.

On the other hand, in the addition of *p*-aminobenzoic acid the yellow spot by *p*-dimetylaminobenzaldehyde was observed at the Rf value of 0.88 depending on the reaction with *p*-aminobenzoic acid as stabilizer itself. In this study *p*-aminobenzoic acid and *p*-aminobenzoylglutamic acid which were supposed to be contained as a component of folic acid in irradiated samples were not detected with *p*-dimethylaminobenzaldehyde. Because the detection by colored spot requires generally more enough quantity for visible as compared with the fluorescence analysis. Futher investigation will be reported in the latter paper.

Summary

The gamma irradiation from Co^{60} was carried out on the alkaline solution of folic acid, simultaneously compared with sunlight exposure. Relations between the concentrations of folic acid (100, 50 and 10 mg%) and irradiated doses, and protective effects of stabilizers (DL-methionine and *p*-aminobenzoic acid) were studied by the polarographic, spectrophotometric, and paper chromatographic methods.

1) Organoleptic changes in gamma irradiated (with 3.0×10^6 r.) folic acid solution were not so much greater than that of the sunlight exposure in the weather of November for 3 hours.

2) At the same levels of irradiation dose, folic acid is more labile in lower concentration than in higher.

3) As stabilizers, DL-methionine and *p*-aminobenzoic acid are effective for protection of folic acid against irradiation.

4) Polarograms of folic acid in gamma irradiated solution gave two waves, the one for folic acid and the other for unknown product. However, when the stabilizers were added, the other wave for unknown product was not observed.

5) Folic acid yields several pteridines and *p*-aminobenzoylglutamic acid by gamma irradiation as well as sunlight exposure.

6) It has been assumed that the cleavage of pteridines was not occurred in gamma irradiation in this experiment.

Acknowledgments

The authors express their sincere gratitude to Messrs. M. Namiki and S. Okazawa, the staffs of the Scientific Research Institude for their kindly support to gamma irradiation.

We also wish to express hearty thanks to Mr. T. Suda for his participation in the present study.

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VERTEBRAL CHARACTERS OF A CONGRID FISH, *ASTROCONGER MYRIASTER*, TAKEN FROM THE TOKYO BAY*

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(Received February 15, 1958)

The number of vertebrae of the anguilline fishes interests as "permanent" character in the field of systematics as well as binomics. We have known this character on a few species of Japan; on the congrid fish, *Astroconger myriaster* (Brevoort), no vertebral description is published before Kubo and Takagi (1957), who refer to it preliminarily. The present authors will now give some further informations in relation to the characters of vertebrae of that species statistically and morphologically; in the anguilline fishes those statistical studies request a preceding morphological examination of the posterior or last some vertebrae.

The fish here mentioned is known as an important comestible species from the Tokyo Bay, where it is mostly catched by special long-line fishery for all seasons at any rate.

The present authors wish to acknowledge especially their indebtedness to Prof. Itsuo Kubo, for his kindful supervision and encouragement through this study. It is supported by a Grant-in-aid for the Co-operative Research (Agriculture) from the Ministry of Education, 1956.

Material and Methods

Samples of totally 80 in number, and 215–608 mm. in body length are all collected by the courtesy of the Eastern Haneda Distributing Office, Tokyo, during December 30, 1956–January 20, 1957. (Table 1.)

Table 1. Range of body length (B. L., mm.) and body weight (B. W., gm.) of 80 specimens catched in the dates below. Indivs., number of individuals.

Date	Indivs.	B. L.	B. W.
Oct. 30, '56	5	438–476	114.5–154.5
Nov. 13	13	391–551	99.0–210.5
Nov. 21	20	215–608	13.5–304.0
Dec. 22	29	228–385	15.0– 73.5
Jan. 22, '57	13	366–493	66.7–171.5

Counting the number of the anguilline vertebrae, it is necessary to examine some vertebrae in caudal terminal part, as well as to make a distinction between abdominal and caudal vertebrae (Ege 1939: 8–9, fig. 3). The dissection of specimens

* Read before the vernal meeting for 1957 of the Japanese Society of Scientific Fisheries, Tokyo, on April 3, 1957.

in two parts may be useful for that purpose.

After measured and weighed, raw samples are fixed in hot water of 70–80°C for 10–15 minutes, and dissected at about 60–80 mm. distance from caudal end, from convenience in work. The vertebral counts is then available by these parts; skeletal specimen with skull made from the fore part of the dissected body, and its smaller posterior part, possibly exposed at a given side of the bone, and disposed under staining and clearing treatments based on the BERTIN (1941)'s method.

As for the staining arrangement, BERTIN says the optimum temperature of 25°C of his prescribed solution of Sodium Sulphalizarinate. Our specimens are actually treated with by house temperature of 7–15°C in winter, and agreeable specimens are given after ca. 48 hours at 7°C, ca. 40 hours at 10°C, and ca. 24 hours at 15°C.

The total number of vertebrae given by those parts are counted from the atlas to the "final or terminal" vertebra (GOSLINE 1950: 312, 313, fig. 7b).

Results

1) The number of vertebrae

The total number of vertebrae is 140–148 in range, and its mode is in 145. The mean value is 144.78 in this case. The number of abdominal vertebrae is 49–53 in range, 51 in mode, and its mean is 51.20. As for the number of

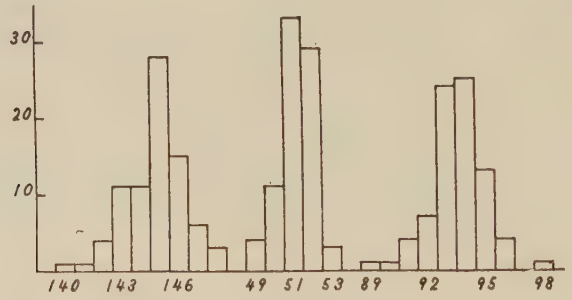

Fig. 1. Variation of the number of total (left), abdominal (middle), and caudal (right) vertebrae of *Astroconger myriaster*. Abscissa, number of vertebrae; ordinate, number of individuals.

Table 2. Range mode (M_0), mean ($\bar{x}$), standard deviation (s), value of Chi square test of normality (degree of free in parentheses; *, available in confidency of 95%), and confidence interval (Interval, in confidency of 95%) of the number of total, abdominal, and caudal vertebrae.

Vertebrae	Range	M_0	$\bar{x}$	s	χ^2-test		Interval
Total	140–148	145	144.78	1.57	(6) 8.54	*	$144.34 \leqq m \leqq 145.22$
Abdominal	49– 53	51	51.20	0.90	(2) 4.44	*	$51.00 \leqq m \leqq 51.40$
Caudal	89– 98	94	93.58	1.41	(7)12.73	*	$93.27 \leqq m \leqq 93.89$

caudal vertebrae, these values are 89–98, 94, and 93.58 respectively. These vertebral numbers are rather agreeably fitted in normal curve of distribution, independently of size composition of samples, which is represented by an assymmentrical curve as usual. (Fig. 1, Table 2.)

The relationships between the three pairs of total, abdominal, and caudal vertebrae are figured in Table 3. The correlationship is effectively recognized between the pair of total and caudal vertebrae, as well as between that of total and abdominal vertebrae. In the former pair, the coefficient of correlation is of 0.821 (Table 4), and in the latter one this figure of 0.443; as for those pairs, the significance is recognized in the level of 95%. Meanwhile the abdominal and caudal vertebrae are found to be independent each other of the number in question.

Table 3. Coefficient of correlation (r), value of t-distribution test in significance of 95% (*, significant in the said level), and confidence interval (Interval, in confidency of 95%) of the pairs of total and caudal ($T\times C$), total and abdominal ($T\times A$), and abdominal and caudal ($A\times C$) vertebrae.

Pair	r	$t_{.05}$-test		Interval
$T\times C$	0.821	12.699	*	0.734–0.882
$T\times A$	0.443	4.259	*	0.247–0.603
$A\times C$	−0.149	1.331		——

Table 4. Correlation table of the number of total and caudal vertebrae.

Caudal vertebrae	Total vertebrae 140	141	142	143	144	145	146	147	148	Total
89		1								1
90	1									1
91			2	2						4
92			1	4	2					7
93			1	2	8	12	1			24
94				3	1	12	8	1		25
95						4	5	3	1	13
96							1	2	1	4
97										0
98									1	1
Total	1	1	4	11	11	28	15	6	3	80

2) Morphology of the posterior vertebrae

Of the posterior vertebrae, the latter four, especially two ones including the terminal vertebra are remarkably characteristic. (Fig. 2.) In these vertebrae the distinct tip of neural spine points forewards, while it looks reversely in bones before those four ones. The principal character of the last two bones appears in their haemal arch and spine. On both vertebrae, more or less distinguishable haemal spine of narrow spatulate shape extends backwards each

other. At the base of the spine of the terminal vertebra is a larger "foramen (Gosline 1950: 313)," sometimes with a smaller hole which is to follow the larger one. These small pores occur frequently by one or two at the haemal arch in some other vertebrae.

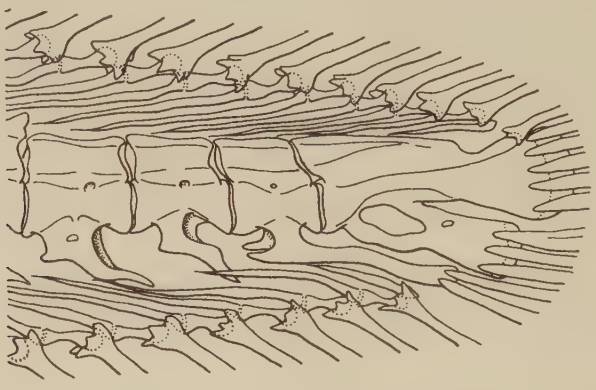

Fig. 2. Posterior part of caudal vertebrae of *Astroconger myriaster*, from a specimen of 43.8 mm in body length and having 144 vertebrae in total, sex unknown. Lateral view from left side, ×15.2. (Drawing by the senior author, after Kubo and Takagi 1957.)

The prolonged end of haemal spine of those bones, as well as the extremity of the "terminal" centrum, is furnished with fin rays. These fin rays on the three parts, treated as caudal rays as a whole, are 6, 3, and 2 in number from upper to lower respectively.

It may be another speciality that upper most fin ray on haemal arch of terminal vertebra can be furnished with a hook-like process upward near the fin ray base.

Discussion

Of the Japanese conger, *A. myriaster*, no description referred to the number of vertebrae has been published, as mentioned above, while the myotomes in its *leptocephalus* stage are already observed.

The *Leptocephalus lacrymatus*, described by Franz (1910: 17, Pl. 3, fig. 3) is said to be a synonym in a larval stage of the fish here mentioned (Uchida 1932: 24), the myotomes of which are 140–142 in number in 100–130 mm. length of body. According to Uchida (op. cit.; 1947: 1755, fig. 4909), those of approximate lengths extend before metamorphosis to 139–147 in the number in question. This value is almost equivalent to the number of vertebrae given by the present authors.

According to Bertin (1951: 138–139, 141, fig. 42, 1956; 133–135, fig. 42), Grassi (1913) and Schmidt (1906–1916) achieve a genetical observation of the caudal bone including the terminal vertebra on the European eel, *Anguilla anguilla* (Linneus). Comparing our present observation with theirs, the conger is found to take somewhat primitive specialization, or the posterior vertebrae of

the adult conger shows apparently a very similar form with the young eel in the elver stage, rather than in the *anguillette* stage.

Those two fishes are supposed to be a representative each other on the two phylogenetical stems of the anguilline fishes, and both of them present an ancestral form of each stem. (Regan 1912, Matsubara 1955: 326, 329.)

Gosline (1950: 313, fig. 7; 1951: 304, fig. 10) shows the osteological detail of the same part in some ophichthids regarded as a specialized form of the same stem as the congrids are subjected to. They receive some remarkable degeneration, and, as far as on the form of this part, they seem to have rather little similarity with the congrids.

Moreover it is interesting that from the other osteological results, the congrids have been recognized their more or less stronger degeneration than the anguillids (Matsubara op. cit.: 329). It seems an analogy with the posterior end of the back bone as seen here.

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A STREPTOCOCCUS PATHOGENIC TO FISH

Toshikazu Hoshina, Tokuo Sano and Yoshimasa Morimoto

(Received Dec. 10, 1957)

Streptococci occur mainly in human or warm-blooded animals or dairy products, but there are some species isolated from water. To refer to literature we could not find any record of streptococci pathogenic to fish. We found a species of *Streptococcus* from diseased rainbow-trouts collected in March and April of 1957 at Kimura Trout Farm in Kannami Village, Shizuoka Prefecture. The malady occurred from March to April of 1957 at the trout culture pond and considerably high mortality, about 0.3% per day in a population of 8400 kg in weight of the rearing fish of 10~20 cm length caused.

The present paper deals with a memoir on the disease in special reference to the causative bacteria.

We acknowledge to Mr. Shinzō Kubota of Tokyo University of Fisheries for their aids during the course of the experiments, and also, to Lecturer Michizo Suyama of the same university, who kindly placed at our employment the apparatus of his laboratory, necessary for the present study.

A part of the expence for this study was defrayed by the grant in Aid for Experimental Scientific Reseach of the Ministry of Education, to which we offer our cardinal thanks.

1. Symptoms and anatomical findings

The diseased fish showed nearly normal appearance, but in advanced stages they became inertness and ceased by and by showing abnormal swimming such as treading water or recumbent posture. On dissection, the anus and intestine showed marked congestion in almost all the cases and the intestine contained a small amount of mucous fluid presenting reddish colour. The liver showed dark red colour due to a marked congestion or the colorations like fatty degenerated liver. The kidney was considerably swollen, however its coloration or other macroscopical findings were normal.

Under the microscope, any kind of parasites was not found from the gills, skins and intestines. However a species of cocci was found without exception in the smear preparations (stained with Pfeiffer's solution and May-Giemsa's method) made from the heart blood, spleen, liver and kidney (10 fishes were examined on 13 April, 1957).

Histologically, the findings were not peculiar. Sections of heart, kidney, liver and intestine, all presented various features of necrosis and disintegration of the tissue cells (Fig. 1, A and B). However, severe changes were confined to the intestine.

The sections of intestine revealed that the epithelial tissues have been entirely destroyed in severe cases. The blood vessels of the subepithelial connective

tissue were congested; the muscular layer were similarly inflamed. Considerable infiltrations of cells were observed in the subepithelial and *muscularis muscosae*.

The sections of liver exhibited sporadically small necrotic parts; the blood cells in the vessels appeared as homogeneous or granular substance sometimes containing necrotic nuclei.

That of the kidney presented the various necrotic figures, viz, hyalin-droplet degeneration or autolysis of epithelial cells of urinary canalicululi: pycnosis of their nuclei and etc., and the excretory canals showed that the cavities were filled with degenerated epithelial cells. In the heart, the degenerative changes were observed at the musculature of endocard.

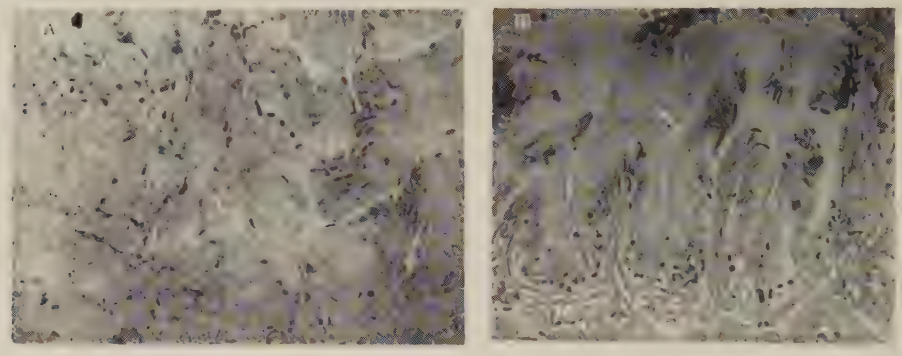

Fig. 1, A. Cross section of heart by paraffin-method, stained with Delafield's haematoxylin and eosin, ×300. The mark shows the degeneration of the musculature of endocard.

B. Cross section of intestine prepared by same method, ×300. The mark shows the necrotic feature of the epithelial tissue.

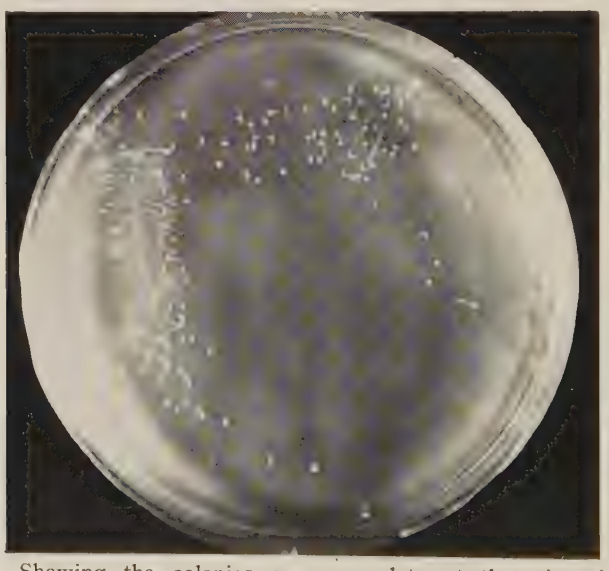

Fig. 2. Showing the colonies on agar plate at that time isolated from the liver of the diseased fish (incubated at 22°C for 72 hours).

2. Isolation of the organism

At the first time the isolation of bacteria was carried out on 30 March, 1957 by using five diseased fish (16.5~20.0 cm in body length) which were packed in ice and brought to our laboratory. With beef extract agar (pH 7.0) as a medium, cultures were made of the liver and kidneys of the materials dissected aseptically. After four days of incubation at 22°C, visible colonies appeared on the cultures with few exceptions and they were pure growth of a coccus in short chain-formation. As the investigation showed above-mentioned results, so the second undertaking of isolation was carried out on 13 April, 1957 to make sure of the fact. This time, it was made at the trout culture farm by using five affected fishes (10.3~21.1 cm in body length) just taken from the pond. The organism isolated from the liver and kidney was all the same to the first experiment (Fig. 2).

3. Pathogenicity of the organism

The pathogenicity was tested by inoculating the organism to several kinds of test animal. The inoculator was prepared by suspending about four mg of the cultured organism (on agar slant at 22~23°C for 24 hours) in 10 cc of sterilized physiological salt solution.

The strain used for the test was isolated on 30 March 1957 from the kidney of one diseased fish.

A. Pathogenicity for rainbow-trout.

Serial experiments started on 13 April, 1957 at Kimura Trout Farm, keeping the experimental animals in small ponds (60×90 cm). Each experimental pond had been supplying plenty water and the temperature was 16°C at all times. The perfectly healthy fish varying 55~100 g in body weight taken from the pond were used for the experiments.

Exp. 1: Six rainbow-trouts, *Salmo gairdnerii*, received a intramuscular injection of 0.3 cc of the suspension. All the fish died within 3 to 12 days after the inoculation. They showed generally the congestion of liver, enteritis, muscular necrosis and hemorrhage at the site of inoculation. Smeared preparations taken from their hemorrhagic muscular tissue, heart, spleen, liver and kidney revealed the presence of the coccus. The cultures made from the liver and kidney of four fishes proved the recovery of the organism.

Exp. 2: Six fish were injected intraperitoneally with 0.3 cc of the suspension. All the fish died within 5 to 12 days. On autopsy, they exhibited marked congestion of liver, enteritis, peritonitis, swelling of spleen and kidney. The isolation of bacteria from the liver and kidney of four fish proved the growth of the organism.

The examination of smeared preparation made from each viscera of the fish revealed the presence of the organism.

Exp. 3: Five fish received rectal injection with 0.1 cc of the suspension (at this case, about 20 mg of the bacteria were suspended in 10 cc of sterilized

physiological salt solution). All the fish died within 2 to 12 days. The anatomical findings were similar to that of Exp. 2. The bacterial cultures were omited.

Exp. 4: Four fish received gastric injection with 0.1 cc of the suspension (the concentration was same to that of Exp. 3). Two fish died within two to five days and remains survived for a long time. Cultures made from the liver and kidney of the two fish proved the recovery of the organism. The pathological changes were almost same to those of Exp. 2 and 3.

B. Pathogenicity for carp, gold fish, eel and frog.

The experiments were tried on 15 May, 1957 except the tests against frog at the Yoshida Fish Cultural Laboratory Attached to the Tokyo Univ. of Fisheries. Small concrete aquariums (90×90 cm) were used to keep the testanimals. They were obtained from the rearing fishes at the laboratory. The water temperature of the aquariums was 19.0~24.0°C during the experiments.

Exp. 5: Five carps, *Cyprinus carpio* L, varying 3.0~5.5 g in body weight were injected intramuscularly with 0.3 cc of the suspension. All the fish survived for three weeks without any sign of abnormality. Dissected all the fish on 6 June 1957, any pathological changes were not found. The bacteriological examination were omited.

Exp. 6: Five carps (3.0~4.0 g in body weight) were injected intraperitoneally with 0.3 cc of the suspension. One fish died on the third week without showing any recognizable abnormality. This fish and remains were dissected at the same day. They showed generally the slight kidney-dilation and hepatitis, however, the other organs were almost normal. Cultures made from the liver of the five fish had completly pure growth of the organism.

Exp. 7: Five gold fish "Wakin" (body weight 3.5~5.0 g) were intramuscularly with 0.3 cc of the suspension. All the fish survived without any abnormality. When they were dissected three weeks after, slight hepatitis was found generally, however, the other viscera were almost normal. Smeared preparations taken from the liver and kindey of the five fish revealed the presence of the coccus.

Exp. 8: Five gold fish (body weight 4.0~6.5 g) received intraperitoneal injection (0.3 cc of the suspension). And all the fish died within 17 to 19 days. The anatomical and bacteriological examination were omited.

Exp. 9: Five eels, *Anguilla japonica*, of 16.5~28.5 g were injected intramuscularly with 0.3 cc of the suspension. All the fish survived without showing any morbid symptom. They were dissected in the third week, however, abnormalities were not found. Any organism was not found in the smeared preparations made from the liver and kindey of the five fish.

Exp. 10: Five eels (17.0~25.0 g) received intraperitoneal injection (0.3 cc of the suspension). At the second week, one fish fell into low activity. Although all the fish did not show marked abnormality, they died within 17 to 20 days. The anatomical and bacteriological studies were omited.

Exp. 11: The experiments were tried on 6 August, '57. Frogs, of 20 g in average weight, (*Rana nigromaculata nigromaculata*) used for the experiments were collected from the environs of the laboratory. One group of the frogs

(consisting from five heads) received intramuscular injection into the leg, and the other (same number) did intraperitoneal injection of 0.3 cc of the suspension respectively. All the frogs injected intramuscularly survived without any abnormality, on the contrary, all the frogs received intraperitoneal injection died within a week. The anatomical and bacteriological examinations were omited owing to the studies involved.

C. Pathogenicity for mouse.

Two groups of mice (10~13 g), each consisting five heads, received intraperitoneal injection of 0.3 cc or 0.5 cc of the suspension respectively. All the animals received the injection of 0.5 cc and one mouse in the group injected with 0.3 cc died within 14 to 15 days. On autopsy, peritonitis, hepatitis, enteritis, dilation of kidney, spleen and pneumonia were found on all the animals. Smeared preparations revealed the presence of the organism without exception. Cultures made from liver, kidney, spleen and heart proved recovery of the organism.

From the above-mentioned experiments, it may be recognized that the organism is pathogenic for rainbow-trout. The fish is attacked readily with the organism by intramuscular, intraperitoneal, gastric or rectal injection. Rainbow trout (55~100 g in body weight) injected intramuscularly or intraperitoneally with the organism (about 0.012 mg) fell in sickness with the lapse of several days and died within about two weeks. Carp, gold fish, eel and frog are attacked also by the organism, if they are inoculated artifically with the organism. These animals are generally more resistive than rainbow-trout, therefore the latent periods are comparatively long. It is interesting fact that the fatal influence was observed only in the case of intraperitoneal injection. The intramuscular inoculation had no effect for the test-animals in practice, however, smeared preparations taken from liver and kidney proved the presence of the organism (Exp. 7). The organism is also pathogenic for mouse.

4. Characteristics of the isolated bacteria

The organism presented weak growth in ordinary beef extract medium[1] (poly-peptone 10 g, beef extract 7.0 g, NaCl 2.5 g, distilled water 1000 cc, pH 7.0). The growth in the following medium[2] was more abundant than above-listed medium.

Poly-peptone	15 g
Yeast extract	5 g
Glucose	5 g
K_2HPO_4	0.5 g
KH_2PO_4	0.5 g
NaCl	2.5 g
Distilled water	1000 cc
pH	7.0

The growth of the organism in 10 cc of the medium[1),2)] at 22°C for 24 hours

was measured by using photo-electric colorimeter (filter 660) and following results were obtained.

Medium	Optical density
1	0.03
2	0.18

Therefore, the medium[2] was used for the subsequent study.

A. Morphological, cultural and biochemical characteristics.

Morphology: Oval or spherical cocci occurring a short chain or a pair, 0.62~6.65 μ in diameter. Not encapsulated. Non motile. Gram-positive, but sometimes decolorizing cells were observed. Not acid fast.

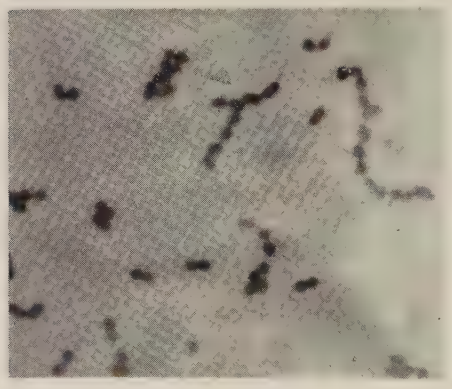

Fig. 3. Showing the Streptococci stained with Pfeiffer's solution, ×1840. (cultured on the medium[2] described in page 61).

Agar plate: Small, round, whitish colonies with convex surface and smooth entire. At 22°C of four days culture, colonies 0.5~1.0 mm in diameter (Fig. 2).

Agar slant: Whitish, semitransparent and smooth surface growth with homogeneous margin. Condensed water faintly turbid with white, granular precipitate.

Endo's medium: Small, round and pinkish colonies with convex surface, smooth entire and somewhat brilliant.

Potato culture: Very scanty growth of gray-whitish color at 22°C for four weeks. The medium changeless compared with the control.

Gelatin stab: No liquefaction. Gray-whitish, smooth, somewhat elevated surface growth, poor and white filiform in track.

Bouillon: Comparatively scantily turbid, clearing later with abundant white sediment.

Milk and litmus milk: Produced a soft clot within about three weeks at 22~25°C. The reaction acidic. Litmus reduced before curdling milk.

Blood agar: The cultures were tried on two kinds of blood agar, viz, rabbit's blood agar and rainbow-trout's blood agar. Each medium contained 10% of the blood. Growth on rabbit's blood, whitish, smooth, elevated and somewhat glossy colonies (surface growth). The medium changeless. Rainbow-trout's blood agar; dirty, gray whitish to slight verdigris, elevated and somewhat glossy surface growth at 22°C, within seven days culture. The medium presented a narrow chocolate colored zone, surrounding the colonies.

Mackonkey's bile salt peptone agar: Very scanty growth at 22°C within a week.

Bile medium: Invisible growth at 22°C for 24 hours, but the medium changed yellowish brown at the lower part of the test tube.

Action for carbohydrates: By using bromthymol blue peptone yeast extract* as a basal medium, the media were made to contain 1% of each carbohydrate and cultured at 22°C for a week. The results obtained are as follows:

CARBOHYDRATE	ACID	GAS
Monosaccharides		
Arabinose	+	—
Xylose	+	—
Rhamnose	+	—
Glucose	+	—
Mannose	+	—
Galactose	+	—
Fructose	+	—
Sorbose	—	—
Disaccharides		
Maltose	+	—
Cellobiose	+	—
Lactose	+	—
Sucrose	+	—
Trehalose	+	—
Polysaccharides		
Raffinose	+	—
Starch	—	—
Glycogen	—	—
Dextrin	+	—
Inulin	—	—
Alcohols		
Mannit	+	—
Dulcit	—	—
Glycerin	+	—
Inosit	—	—
Sorbit	+	—
Glucossides		
Salicin	+	—
Esculin	+	—

Some biochemical and biological characters: The experimental results are showed in Table 1.

Relation to oxygen: The organism grows in the both condition of aerobic and anaerobic, but more in aerobic condition.

Relation to temperature: The cultures of the organism taken with platin loop from broth culture (at 22°C for 24 hours) into the test tubes of 10 cc of broth were made at temperature ranging from 0° to 45°C. The growth was

* Poly-peptone 15 g
Yeast extract 5 g
NaCl 2.5 g
Distilled water 1000 cc

Table 1. Biochemical and biological characteristics.

Items	Resutls
Indol-formation	Negative
H_2S-formation	Negative
Formation of lactic acid from glucose	Positive
Final pH in glucose broth	5.5~5.0
Formation of NH_3 from peptone	Positive
Formation of nitrite from nitrate	Negative
Catalase reaction	Negative
Hydrolysis of starch	Not hydrolyzed
Hydrolysis of sodium hippurate	Not hydrolyzed
Production of hemolysin	Not produced
Utilization of $NH_4P_2O_4$ or urea as sole source of nitrogen	Not utilized
Tolerance against NaCl and methylene blue.	Tolerant for 6.0 % of NaCl and 0.1 % methylene blue
Thermal death point	Killed at 60°C 10 minutes and at 65°C one minute

measured by same method described in page 66. The results obtained are showed in the Table 2 and Fig. 4. Within seven days, the organism does not grow at 0° and does scantily at 6°, and well at 10°C within three days.

Table 2. The effect of temperatures on the growth of the organism.

Temp. °C	0	6.0	10.0	13.8	17.5	21.2	23.8	26.8	30.7	34.8	39.6	45.0
Growth (Optical density)	—	—	—	—	1.68	4.79	5.38	5.48	5.38	5.13	4.82	2.05

Relation to pH of medium: The cultures at 22°C for 24 hours in 10 cc of broth (were prepared by adding HCl or NaOH into the broth and adjusted the pH by using Beckman pH meter) of different pH were measured by same method described above. The results showed that the organism does not grow at pH 5.0, 11.0 and optimum pH is 8.0~8.5 (see Fig. 5).

B. Resistance of the organism to antibiotics.

The *in vitro* sensitivity of the organism was determined through the following experiments. A series of test tubes containing each antibiotics made by adding 0.2 cc of serial concentration of the antibiotics to 9.8 cc of bouillon, was

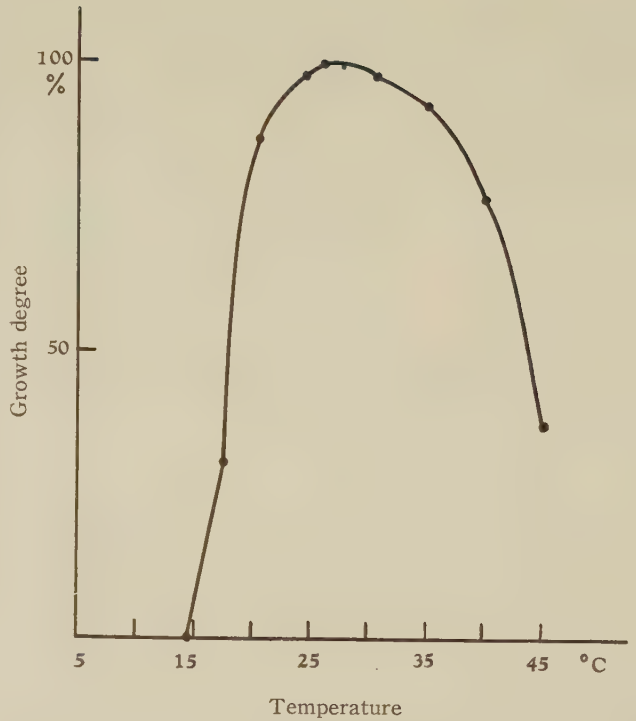

Fig. 4. Showing the growth curve at each temperature. The growth at each temperature was calculated on the basis of the growth at 26.8°C which was determined as 100%.

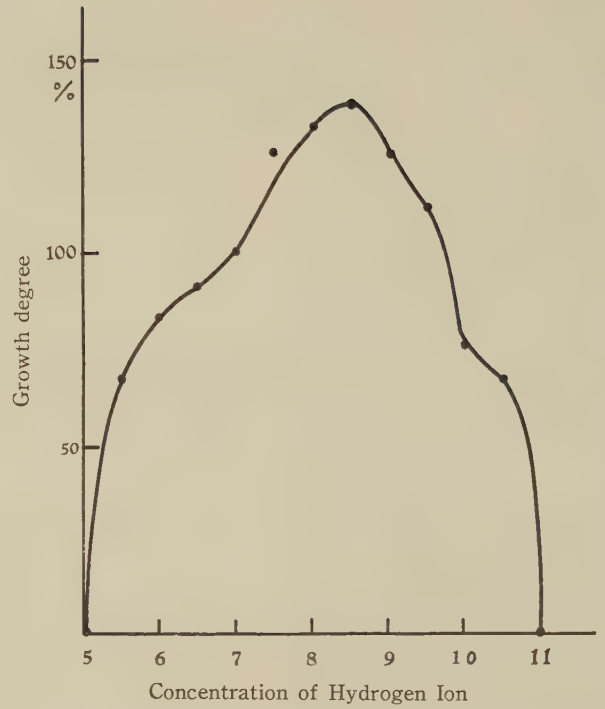

Fig. 5. The growth curve showing the effect of pH on the organism. Calculated the growth degree at each pH on the basis of the growth at pH 7.0 which was determined as 100%.

prepared. Test tube containing 9.8 cc of bouillon and 0.2 cc of sterilized water was served as control. These test tubes were inoculated with a loopful (diameter of loop 3.0 mm, diameter of the wire 0.6 mm) of the organism cultured in 10 cc of bouillon at 22°C for 24 hours. The growth of the organism was measured by using photo-electric colorimeter (filter 660) at the end of 24 hours (cultured at 22°C). The reading were treated on comparison with that of the control tube which was regarded as 100 % growth.

The results obtained are compiled in the Table 3.

Table 3. Resistance of the organism to antibiotics.

Antibiotics	Milligrams of antibiotics in 10 cc of bouillon	Growth (%)
Aureomycin	0.0004	99.42
	0.0005	98.72
	0.0006	98.95
	0.0007	94.56
	0.0008	87.85
	0.0009	67.05
	0.001	0.92
	0.002	0.00
	0.004	〃
	0.006	〃
	0.008	〃
	0.010	〃
Streptomycin	0.06	100.00
	0.08	98.26
	0.10	97.57
	0.14	94.79
	0.16	94.79
	0.20	31.21
	0.40	1.15
	0.60	0.00
	0.80	〃
	1.00	〃
Teramycin	0.002	64.97
	0.004	19.19
	0.005	3.00
	0.006	0.00
	0.008	〃
Penicilin G	2 (unit)	67.05
	4	49.96
	6	42.77
	8	〃
	10	33.52
	20	26.58
	40	5.78
	60	00.0
	80	〃

Among the tested antibiotics, Aureomycin was most effective to arrest the growth of the organism and Streptomycin was most inferior.

C. Remark

Judging from the abve-described characters, the present organism may belong to the group of non-hemolytic, enterococcus of Lactobacteriaceae. The

present form may be identified with *Streptococcus faecalis* Andrews and Horder though there are some discrepancies between the present form and the species in relation to pH, temperature and source.

5. Discussion

The mortality of rainbow-trout which happened at Kimura Trout Farm from March to April, 1957, was due to infection with *Streptococcus faecalis*. Recently, various fish diseases believed to be bacterial infection have been described by many workers, however, the diseases caused by pathogens of warm-blooded animals are not found yet. Solely, one report of a bacterium pathogenic for warm-blooded and cold-blooded animals is presented in the literature (Griffin and Snieszko, 1951).

The disease at above-mentioned fish farm is different from the various diseases have been found in salmoid fishes by the absence of local lesions in the skin, fins or muscular tissues. It is characterized by general infection with the pathogen and showing enteritis, hepatitis and dilation of kidney, but the pathological changes are different from the kidney disease informed by Griffin[4] (1953).

Further, it was not found such as amaebic infection described by Plehn.[7] At any rate, this disease is a interesting problem as an instance of fish disease which has been caused by the organism of warm-blooded animals. At the same time it is interesting that in what way such pathogen invaded in the trout pond. The fish farm is in the very good surroundings and using spring water conducted by concrete pipe from the source. Therefore, there is no possibility of contamination of the water.

Considering from these facts, though the bacteriological examination of the diet was not carried out at that time, it seems that the diet is questionable as the source. At the present, though the disaster has disappeared, if it appears again hereafter, the authors desire to solve completly the questionable problem.

6. Summary

The disease of rainbow-trout occurred in March of 1957 at Kimura Trout Farm in Kannami Village, Shizuoka Prefecture were studied with special referene to the etiological agent and obtained results are as follows.

There was no evidence that the diseased fishes show the local lesions in the skin or musculartures. Generally, they showed hepatitis and enteritis.

The cultures from the kidney and liver of the diseased fishes revealed the presence of the organism probably identifiable with *Streptococcus faecalis* Andrews and Horder.

The isolated organism showed the pathogenicity for rainbow-trout by intramuscular, intraperitoneal, gastric and rectal injection. The pathogenicity for carp, gold fish, eel, frog and mouse was proved by intraperitoneal injection.

These animals showed comparatively long latent periods against the infection with the pathogen except frog.

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ON A NEW PARASITIC COPEPOD, *PARAPANAIETIS TURBO* N. SP. OBTAINED FROM MARINE GASTROPOD, *TURBO STENOGYRUS* FISCHER

Toshikazu Hoshina and Ren Kuwabara

(Received Dec. 15, 1957)

The lesser author has found a species of parasitic copepod occurring in the mantle cavity of *Turbo stenogyrus* Fischer collected in April and June of 1957 at Kominato, Chiba Prefecture.

At first sight the parasite bears a resemblance to *Parapanaietis tegulae* Hoshina and Sugiura, 1953, but detailed examination of the parasite proved that it seems to be hitherto unknown to science. In this paper is described the copepod, under the name *Parapanaietis turbo*.

We wish to express our thanks to Prof. Dr. Sueo M. Shiino of Prefectural University of Mie, for his kindness presented to our study.

Materials.—The details of the collection of the parasite are shown in the Table 1. The materials were preserved in 70% alcohol. For microscopy they were mounted with lacto-phenol solution.

Table 1. The collection of the parasite.

Date	Nos. of the host examined	Nos. of the host infected with the parasite	Nos. of the parasite found		
			♀ with egg cases	♀ without egg cases	♂
April 7, 1957	1	1	1	2	1
〃 27, 〃	4	3	5	3	4
July 21–22, 1957	34	16	18	9	10

Parasitic status.—It was found the parasites attached mainly on the base of the host's gills (Text-fig. 1). The infected parts showed a considerable swelling in sometimes. The other pathological changes in the host bodies were not observed.

Text-fig. 1. Showing the parasitic status. f, female; m, male; s, swelling in the seat of infection.

CLAUSIIDAE

Parapanaietis turbo n. sp.
(Pl. 1, Figs. 1-6, Pl. 2, Figs. 7-13).

Descriptions.—The characteristics of the parasite are as follows:

Female. Body 2.9~3.4 mm long; uniformly light orange, or the coloration re-

stricted on thorax and in this case, head and abdomen greyish white, in fresh state. Head 0.52~0.65 mm long by 0.67~0.80 mm broad, its frontal margin roundish. Nauplius eye dark reddish, at 0.09~0.14 mm apart from the frontal edge of the head. Cephalothorax 0.86~0.97 mm long by 0.74~0.91 mm broad.

Thorax 1.30~1.56 mm long size; second to fourth segments almost same size; fifth segment much smaller than preceding seg., each segments with rounded sides.

Genital segment rounded laterally, 0.13~0.18 mm long by 0.32~0.37 mm broad. Egg strings 0.71~2.33 mm long by 0.27~0.50 mm broad, easily detachable; eggs rounded, 0.07~0.12 mm in diameter.

Abdomen 4-segmented, gradually narrowed posteriorly, 0.42~0.57 mm long, 0.22~0.27 mm broad at the first segment and 0.17~0.20 mm at the terminal segment.

Caudal rami 0.13~0.15 mm long by 0.04~0.07 mm broad at the broadest part, each with a seta on outer margin just its middle and four apical setae, two of which are prominent.

First antenna 7-segmented, gradually tapering distally, 0.31~0.38 mm long by 0.05~0.06 mm broad at the base, bearing 25~30 setae on the whole segment; terminal segment with 3~4 apical setae.

Second antenna prehensile, 4-segmented; basal segment broadened proximally, about twice as wide as long and with or without a small setiform spine on inner side at the middle of its length; second also twice as wide as long, with a setiform spine on inner margin at the posterior of one third of the length; third bearing two setiform spine on inner side; fourth small, with two apical claws, one of which is stout.

Mandibular blade broad, finely serrated on anteroposterior margins, distal portion filamentous, with a gnathobasis serrated on posterior margin.

First maxilla small, rounded terminally, bearing three apical setae. Second maxilla terminating in two rami; main ramus finely serrated on posterior margin; small ramus finely serrated on both sides. Basal part of second maxilla 2-segmented; distal segment bearing a seta on posterior margin, at little behind from its distal portion.

Maxilliped 3-segmented; first to second segment cylindrical; distal segment small and conical, with a seta.

First to fourth legs biramose; protopodite 2-segmented, second protopodite with or without a seta on outer margin; each endopod 2- or 3-segmented, but that of third and fourth leg 2-segmented; exopod 2- or 3-segmented, but that of fourth leg 2-segmented.

The arrangement of spines and setae on each ramus of first to fourth legs is shown in the Table 2.

Fifth leg uniramose, 2-segmented; basal segment short, bearing with or without a seta on outer side; terminal segment cylindrical, 2~4 times long as wide, with two apical setae.

Male. Body 1.8~2.1 mm long, greyish white in fresh state. Head truncated frontally, 0.46~0.54 mm broad by 0.39~0.49 mm long. Nauplius eye 0.07~0.08 mm apart from frontal margin.

Thorax 0.54~0.67 mm long, gradually narrowing towards posterior. The

dimensions of first to fourth thoracic segment are as follows: 0.12～0.17 mm × 0.43～0.51 mm; 0.15～0.16 mm × 0.37～0.45 mm; 0.14～0.18 mm × 0.31～0.39 mm; 0.13～0.16 mm × 0.26～0.31 mm. Fifth segment fused with genital segment.

Table 2

Ramus / Leg	Exopod						Endopod					
	1st seg.		2nd seg.		3rd seg.		1st seg.		2nd seg.		3rd seg.	
	spine	seta	spine	seta	spine	seta	spine	seta	spine	seta	spine	seta
1st	1	0	4	3 0～1*	3	2～3	0	0～1	2	3～4 1*	2	3
2nd	1	0	3 1*	3 0*	3	3	0	0～1	3 0*	1～2 0～1*	3	2
3rd	1	0	2 0～1*	1 0*	1～2	1	0	0	2	0	—	—
4th	0～1	0	1～2	0	—	—	0	0	1～2	0	—	—

* In the case of 3-joints.

Genital segment enlarged, 0.38～0.45 mm long by 0.33～0.40 mm wide including fifth segment, its posterior margin rounded, bearing two setae on its both posterior corner.

Abdomen 4-segmented, 0.30～0.34 mm long 0.14～0.17 mm wide at the first segment, 0.12～0.13 mm at the terminal segment.

Caudal rami similar to that of female, 0.09～0.10 mm long by 0.04～0.05 mm wide.

First antenna 7-segmented, armed with 28～29 setae on the whole segment, 0.33～0.35 mm long by 0.03～0.04 mm broad at base; terminal segment with 3～4 apical setae.

Second antenna 4-segmented, similar to that of female but terminal segment armed with a setiform spine on outer margin of its distal portion. Mandible, and first and second maxilla similar to that of female, but proximal part of mandibular blade longer than that of female, its serrated portion strongly curved inwards. Maxilliped powerful, 4-segmented; third segment with a setiform spine

Table 3

Ramus / Leg	Exopod						Endopod					
	1st seg.		2nd seg.		3rd seg.		1st seg.		2nd seg.		3rd seg.	
	spine	seta	spine	seta	spine	seta	spine	seta	spine	seta	spine	seta
1st	1	0	1	0～1	3	2～3	0	0～1	2	4 0～1*	2	2～3
2nd	1	0	3 0～1*	3	2～3	3	0	0～1	3 0*	2 0*	3	2
3rd	1	0	2～3 0*	1 0*	2	1	0	0	2	0	—	—
4th	0～1	0	1～2	0	—	—	0	0	1	0	—	—

* In the case of 3-joints.

on inner side at its middle; fourth small, tipped with a slender claw bearing a setiform spine at its inner basal part.

Distal segment of each protopodite with or without a seta on outer side, sometimes bearing a seta on inner side also. Endopod of first to second legs 2- or 3-segmented, rami of remaining two pair of legs 2-segmented. Exopod of first to third legs 2- or 3-segmented; that of fourth leg 2-segmented. The arrangement of spines and setae on each ramus of first to fourth legs is shown in the Table 3.

Fifth leg uniramose, 2-segmented; basal segment with or without a seta on outer side at its terminal portion; terminal segment with two setae of equal length.

Remarks.—The present form bears closely resemblance to *Parapanaietis tegulae*, but it may be distinguish with each other by following differences: Table 4.

Table 4.

Species / Items	*Parapanaietis tegulae*	Present form
Head	with median ridge.	without median ridge.
Distal seg. of 2nd maxilla	a seta lacking on posterior margin.	with a seta.
Distal seg. of maxilliped of female	$\frac{1}{2}$ as long as 2nd seg., bluntly pointed.	$\frac{1}{3}$ as long as 2nd seg., sharply pointed.
Exopod of 1st to 4th leg.	3-segmented except 4th leg which is 2- or 3-segmented.	2- or 3-segmented, but that of 4th leg 2-segmented.
Endopod of 1st to 4th leg.	2-segmented.	2- or 3-segmented, but that of 3rd and 4th leg 2-segmented.
5th leg.	single segment.	2-segmented.
caudal rami.	with five apical setae.	with four apical setae.

In addition to these inconsistencies, there are considerable differences between the both species in the number and arrangement of spines and setae on each ramus of third to fourth legs.

Reference

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PL. I

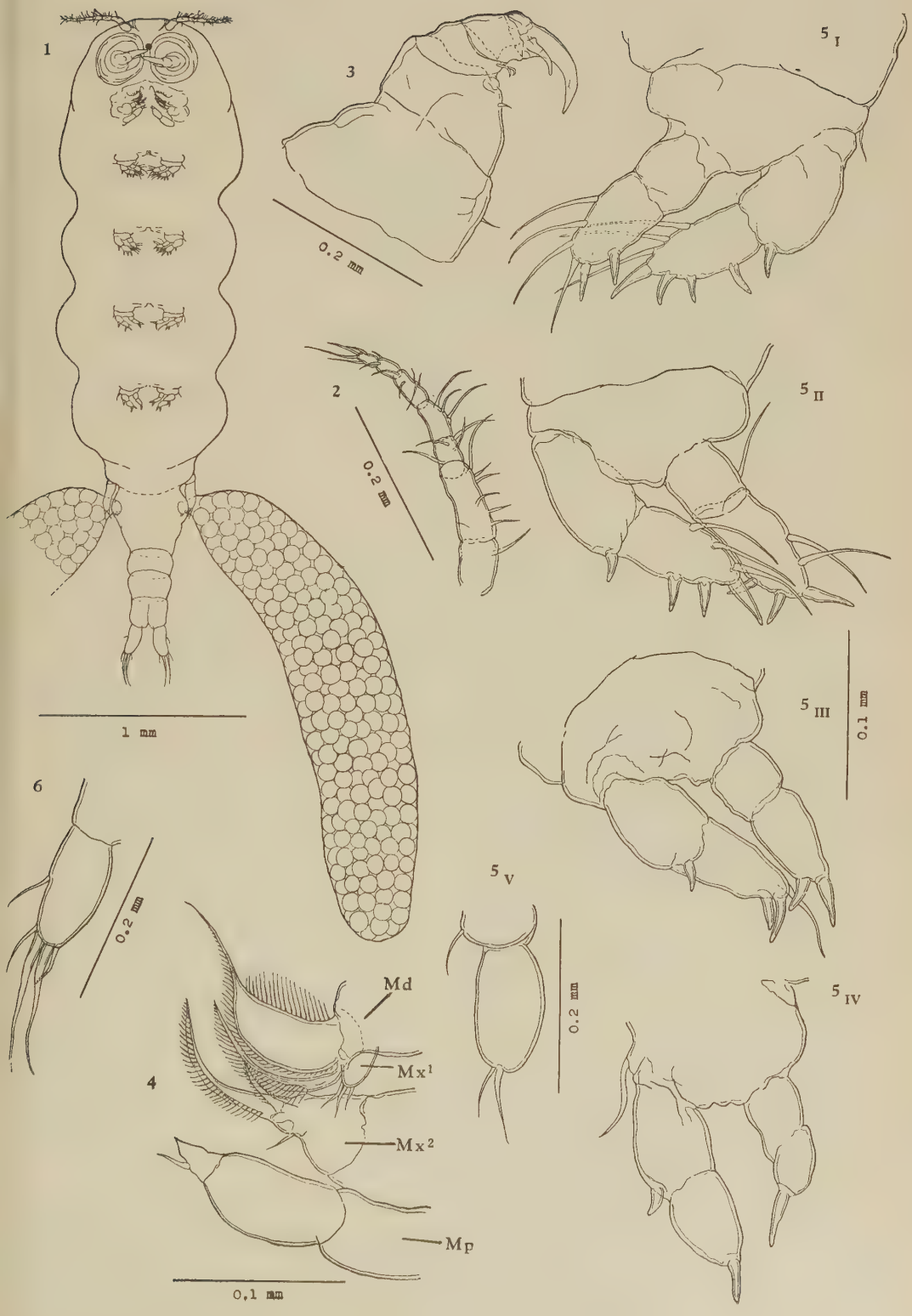

1
1 mm
2
0.2 mm
3
0.2 mm
4
Md
Mx¹
Mx²
Mp
0,1 mm
5 I
5 II
5 III
0.1 mm
5 IV
5 V
0.2 mm
6
0.2 mm

PLATE I

Figs. 1–6. *Parapanaietis turbo* n. sp., female.

Fig. 1. Body of female, ventral view.

Fig. 2. First antenna, ventral view.

Fig. 3. Second antenna, ventral view.

Fig. 4. Mouth parts, ventral view. Md, mandible; Mx^1, first maxilla; Mx^2, second maxilla; Mp, maxilliped.

Fig. 5.I–V. First to fifth legs, ventral view. I, first leg; II, second leg; III, third leg; IV, fourth leg; V, fifth leg.

Fig. 6. Caudal rami, ventral view.

PLATE II

Figs. 7–13. *Parapanaietis turbo* n. sp., male.

Fig. 7. Body of male, dorsal view.

Fig. 8. Fifth and genital segment, ventral view.

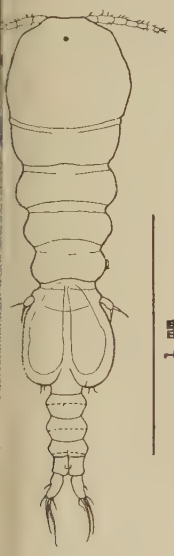
Fig. 9. First antenna, ventral view.

Fig. 10. Second antenna, ventral view.

Fig. 11. Mouth parts, ventral view. Md, mandible; Mx^1, first maxilla; Mx^2, second maxilla.

Fig. 12. Maxilliped, ventral view.

Fig. 13.I–V. First to fifth legs, ventral view. I, first leg; II, second leg; III, third leg; IV, fourth leg; V, fifth leg.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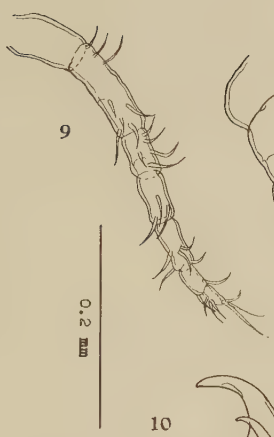
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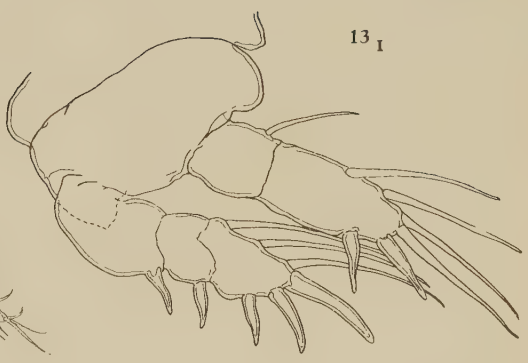
0.2 mm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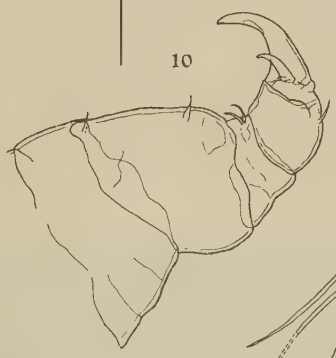
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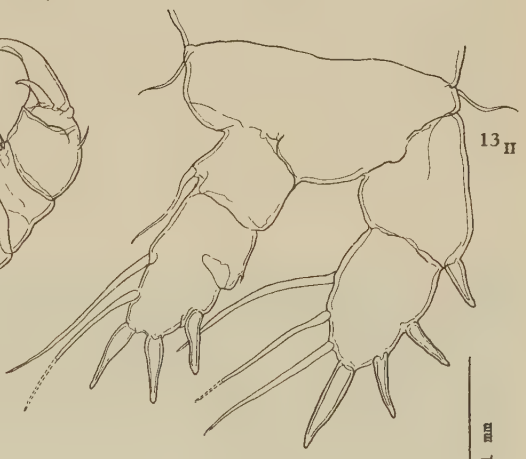
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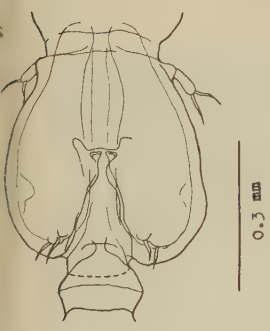
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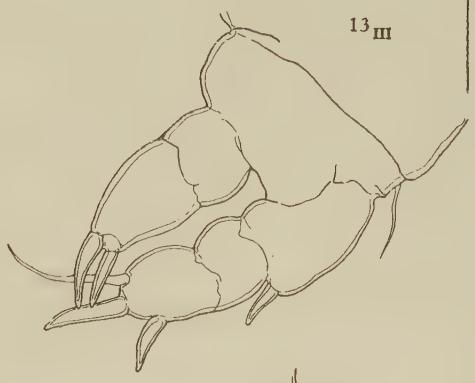
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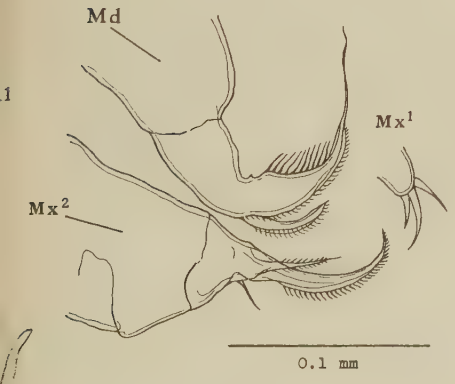
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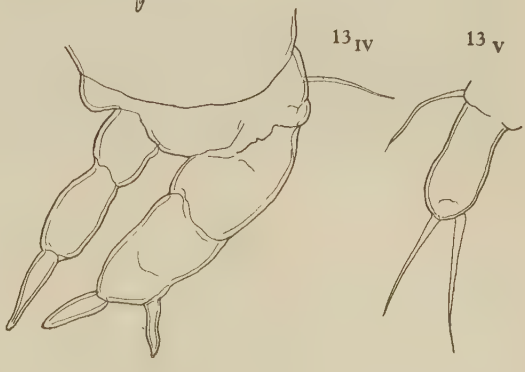
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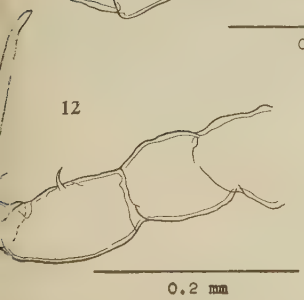
12
0.2 mm

Journal of the Tokyo University of Fisheries, Vol. 44, Nos. 1~2, 1958

ÜBER DIE ELEKTRONENMIKROSKOPISCHEN BEOBACHTUNGEN DES ERREGERS DER VIBRIONEN-SEUCHE DER REGENBOGENFORELLEN

Toshikazu Hoshina

(Eingegangen am 7 Jan. 1958)

Ich habe einige Referaten betreffs bakteriller Erreger von Regenbogenforellenseuche die Furunkulose ähnliche ist, berichtet.

Folgendes ist ein Memorandum von elektronenmikroskopischen Beobachtungen über den Erreger. Die Aufnahmen machte Herr Shigeo Sakata, an dem Laboratorium für Elektronentechnik der Medizinischen Fakultät, Tokio Universität, dem ich für seine Hilfe meinen Dank aussprechen möchte.

Der Stamm, für die Beobachtungen benutzt, wurde aus einer erkrankten Regenbogenforelle am 10. August '57 an Hakojima Forellenzuchtanstalt von Gumma Pref. isoliert. Der Erreger, auf Agarnährboden bei 22°C für 5 und 10 Std. gezüchtet, wurde für Präparation verwendet. Zur Herstellung des Präparates

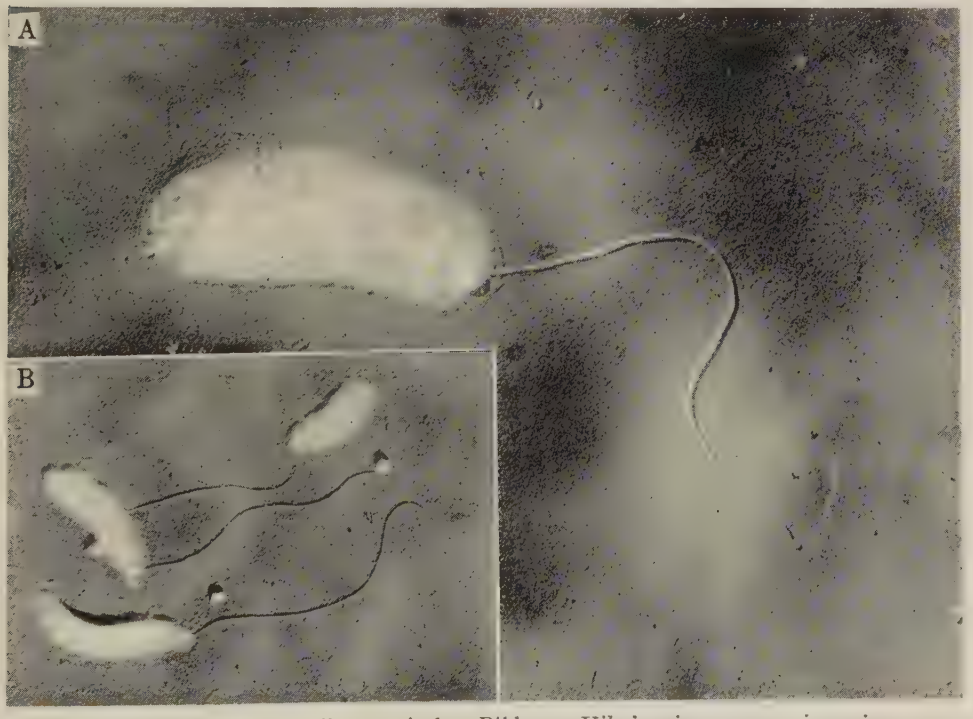

Abb. 1. Elektronenmikroscopisches Bild von *Vibrio piscum* var. *japonicus* Hoshina, 1957

A. Bei 22°C für 5 Std. gezüchtet. × 16,300
B. 〃 10 Std. 〃 × 8,200

wurde die gezüchtete Bakterien in dest. Wasser suspendieren gelassen und ein kleiner Tropfen dieser Flüssigkheit auf Kollodiummembrane übergetragen. Darauf folgte Austrocknung und Schattierung mit Chrom des Materials. Die Aufnahmen wurden mit 75 Kilovoltsstrom ausgeführt.

Der Erreger its monotorische, gekrümmte Stäbchen mit runden od. etwas spitzen Enden, wie Abb. 1 zeigt. Die Länge des Körpers beträgt etwa 1～3 μ, die Breite 0.5～1μ. Die Geissel ist ziemlich dick und etwa 4～7 μ lang; 1.5～5 mal so lang wie der Körper selbst. Die Geissel, deren kleiner Teil in dem Körper begraben ist, entspringt von der Mitte eines Endes des Körpers. Die Zellenmembran ist zart und der innere Teil des Körpers ist locker.

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Journal of the Tokyo University of Fisheries, Vol. 44, Nos. 1~2, 1958

STUDY ON THE DISPOSITION OF FISH TOWARDS THE LIGHT 2. THE STRENGTH OF ILLUMINATION PREFERRED BY FISH

Yutaka IMAMURA

(Received Jan. 15, 1958)

The author has previously pointed to the situation that phototaxis of fish is apt to be diversly estimated depending not only on the strength of illumination but on the baits present, the depth at which fishes swim thus varying generally with the circumstances surrounding them. In the other hand, KAWAMOTO examining the behavior of a sort of dace (*Mugil Cephalus*) says that the extent of change brought about by illumination in the pattern of fish distribution is not proportioned to its underwater intensity. Taking these into account, the author lately examined the effect of illumination at various strengths on the distribution pattern using carp (*Cyprinus Carpio* LINNE) as test fish. The present paper deals with the details of this examination.

PART I. FISH RESPONSE TO NORMAL LIGHT

As for the illumination in which fish are bathed, it is normal that the source of light is situated outside the water. Hence, in this part of work "normal light" in the above sense was used for illuminating the test fish.

Arrangement of experimental set

A concrete tank of the following size was used: 4 *m* in length, 1.5 *m*, in breadth, and 1.5 *m*, in depth. Wall of this tank was lined with tin-plate, while one side of which was furnished with three glass windows, each being 75 *cm*× 50 *cm*. The bottom surface of the tank was sectioned by drawing white lines into 24 sections of an equal area, 50 cm^2. Amount of water was adjusted to be

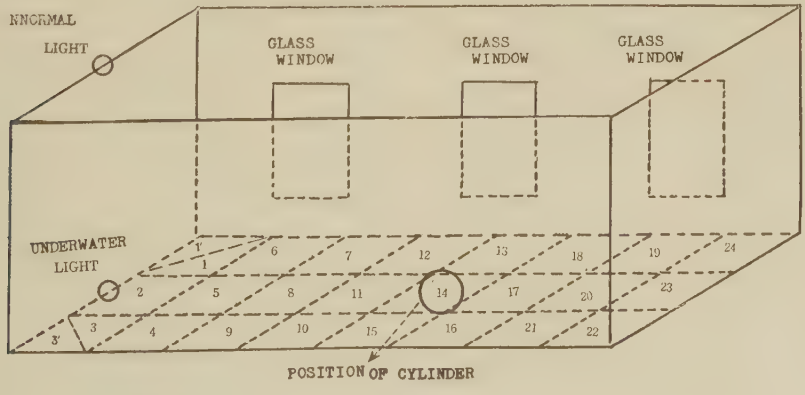

Fig. 1.

60 *cm* in depth. A reflecter white lamp (100 *volt* 300 *watt*) was used as the light source, which was set as shown in Fig. 1. The light was projected at an angle of 45° to water surface. The intensity of illumination was controlled by means of a slidax, while its measurement was done by an underwater lux-meter of MURAYAMA which was kept horizontal at the center of each section on the tank bottom. As test fish 300 individuals of carp (*Cyprinus Carpio* LINNE) were provided in total. Every 50 of them was used in every run. Their average body length was 6.7 *cm*, and their mean weight was 8.3 *gm*

Method of experiment

1) A celluloid cylinder (diameter, 5 *cm*, length, 70 *cm*) was set stood in the tank and the test fish were put into this cylinder so as to be adapted to the dark.

2) The cylinder was then removed out of the tank with simultaneous putting-on the light setting the fish free.

3) Observing the behavior of fish, the pattern of fish distribution was recorded by counting the fish in each section at intervals of five minutes. Such observation was continued for one hour and repeated four times at each definite strength of illumination. Test fish were renewed for each run, but the water

Table 1. (Preliminary experiment).

Section numbers	(G) Number of groups observed	(CT) Correction term	(F) Number of fish observed	(CT) Correction term
1	46	−9	262	−162
2	44	−7	169	−69
3	42	−5	141	−41
4	39	−2	82	18
5	39	−2	85	15
6	46	−9	209	−109
7	44	−7	154	−54
8	39	−2	106	−6
9	36	1	86	14
10	33	4	51	49
11	36	1	94	6
12	44	−7	123	−23
13	39	−2	104	−4
14	35	2	64	36
15	37	0	64	36
16	29	9	51	49
17	35	2	72	28
18	38	−1	87	13
19	31	6	77	23
20	24	14	48	52
21	30	7	57	43
22	35	2	70	30
23	31	6	58	42
24	38	−1	86	14
Σ	890	0	2,400	0
M	37		100	

temperature was kept at 7.2°~7.8°C, in all experiments.

Preliminary experiment

Up to a time not long ago it had been assumed that difference in fish distribution between different sections would be produced purely by difference in the strength of illumination alone. However, it was proved in a preliminary experiment, which was carried out at zero *lux* illumination, that the distribution is affected also by dimension of the tank, the wall effect, and position in which the celluloid cylinder had been kept stood. In this preliminary experiment the fish distributions at zero *lux* were inferred by counting the fish in various sections using momentary lightenings at intervals of five minutes (the duration of lightening was 15~25 seconds).

The correction terms for the errors arising from the said factors, which were determined by this experiment, are indicated in Table 1.

Table 2. (Experiment I-1).

Section numbers	Illumination		Number of groups				Number of fish in total			
	lux	lank	G	CT	CV	CA	F	CT	CV	CA
1	900	4	24	−9	15	23	126	−162	−36	72
2	1,500	5	2	−7	−5	3	5	−69	−64	44
3	1,000	5	15	−5	10	18	26	−41	−15	93
4	950	4	4	−2	2	10	17	18	35	143
5	4,100	6	0	−2	−2	6	0	15	15	123
6	1,300	4	1	−9	−8	0	1	−109	−108	0
7	500	3	10	−7	3	11	22	−54	−32	76
8	500	3	3	−2	1	9	3	−6	−3	105
9	380	3	5	1	6	14	25	14	39	147
10	49	2	10	4	14	22	32	49	81	189
11	227	3	5	1	6	14	47	6	53	161
12	215	3	18	−7	11	19	197	−23	174	282
13	53	2	21	−2	19	27	179	−4	175	283
14	58	2	11	2	13	21	165	36	201	309
15	40	2	10	0	10	18	37	36	73	181
16	26	1	7	9	16	24	38	49	87	195
17	47	2	8	2	10	18	140	28	168	276
18	40	2	21	−1	20	28	320	13	333	441
19	25	1	19	6	25	33	128	23	151	259
20	22	1	2	14	16	24	19	52	71	179
21	21	1	8	7	15	23	63	43	106	214
22	19	1	19	2	21	29	79	30	109	217
23	18	1	8	6	14	22	59	42	101	209
24	18	1	30	−1	29	37	672	14	686	974
		Σ	261	0	261	453	2,400	0	2400	4992
		M	18.7			19	100		100	208

F: Number of fish in total observed.
G: Number of groups observed.
CT: Correction term.
CV: Corrected value.
CA: Corrected values adjusted for comparison.

Experiment I-1. This experiment was run using an illumination being graded from section to section within a range of 4100~18 *lux.*

Experiment I-2. An illumination graded within a range of 980~2.8 *lux* was used.

Experiment I-3. In this experiment the illumination was graded within 110~0.21 *lux.*

In these three experiment the test fish were previously kept confined in the cylinder for an hour so as to become adapted to the dark.

Result of experiment

Behavior of fish. Fish behavior observed in each experiment are outlined in List A. In most cases fish settled down in a place of lower illumination. Fish formed a main group in the dim place, which continually repeated expansion and

Table 3. (Experiment I-2).

Section numbers	Illumination		Number of groups				Number of fish in total			
	lux	lank	G	CT	CV	CA	F	CT	CV	CA
1	370	4	14	−9	5	12	40	−162	−122	0
2	450	4	4	−7	−3	4	10	−69	−57	63
3	350	4	7	−5	2	9	38	−41	−3	119
4	370	4	2	−2	0	7	8	18	26	148
5	950	5	1	−2	−1	6	2	15	17	139
6	500	4	2	−9	−7	0	2	−109	−107	15
7	225	4	3	−7	−4	3	18	−54	−36	86
8	265	4	0	−2	−2	5	0	−6	−6	116
9	110	4	3	1	4	11	16	14	30	152
10	32	3	4	4	8	15	14	49	63	185
11	64	3	7	1	8	15	28	6	34	156
12	58	3	23	−7	16	23	588	−23	565	687
13	20	2	38	−2	36	43	687	−4	683	805
14	11	2	17	2	19	26	196	36	234	356
15	14	2	8	0	8	15	36	36	72	194
16	4.5	1	5	9	14	21	18	49	67	189
17	7.5	2	3	2	5	12	6	28	34	156
18	8	2	17	−1	16	23	134	13	147	269
19	3	1	16	6	22	29	109	23	132	254
20	4.5	1	2	14	16	23	17	52	69	191
21	4.5	1	1	7	8	15	3	43	46	168
22	2.5	1	21	2	23	30	110	30	140	262
23	2.5	1	8	6	14	21	52	42	94	216
24	2.5	1	21	−1	20	27	226	14	280	402
		Σ	227	0	227	395	2,400	0	2,400	5,328
		M	9.5			17.2	100			222

G: Number of groups (observed).
F: Number of fish in total (observed).
CT: Correction term.
CV: Corrected value.
CA: Corrected values adjusted for comparison.

List A. Outlines of the behavior of test fish under a normal light.

Time	Exp. I-1. 4100~18 *lux*	Exp. I-2. 950~2.5 *lux*	Exp. I-3. 110~0.2 *lux*
0 *m* ↓ 5 *m*	Fish scattered once. But there was soon formed a main group at the center of the tank.	The same as Exp. 1-1.	The same as Exp. 1-3.
5 *m* ↓ 10 *m*	The main group migrated toward a lighter zone, the next swimming vividly at random.	The main group was resolved into individual fish swimming about randomly.	The main group moved for a lower illumination place.
10 *m* ↓ 15 *m*	The main group in the high illumination place became somewhat diffused.	A main group formed again in a lower illumination place, the members swimming very calmly.	The main group returned to a lighter place quietly along the wall.
15 *m* ↓ 20 *m*	The main group separated into three groups, whose the largest one moved toward a lower illumination place.	The main group moved for light along the wall of tank, settling meanwhile in a higher illumination place.	The main group became diffused into a form like an elongated array.
20 *m* ↓ 25 *m*	A new main group was formed in the lower illumination place, a few fish swimming about actively in more highly illuminated zones.	The main group migrated to a place of lower illumination.	The main group settled in a dim place.
25 *m* ↓ 30 *m*	A few fish entered the main group and settled in a lower illumination place.	The main group settled in the light region with a few fish swimming about in a high light.	The main group remained settling in the dim place.
30 *m* ↓ 35 *m*	The main group remained in a less illuminated place, a few fish moving towards a lighter.	The same as Exp. 1-1.	The main group resolved into scattered members swimming about at random.
35 *m* ↓ 40 *m*	The main group swarmed calmly in the less illuminated place.	The main group separated into two groups of which the one moving to a lighter place and the other staying in a darker place.	A new main group was formed in a lighter place. The group moved to a darker place in the meantime.
40 *m* ↓ 45 *m*	The main group scattered into individual members, moving for light. But these fish returned again to a darker place.	The two groups joined into one which wavered between a dark place and a lighter place.	The main group returned from the dim place to a lighter zone.
45 *m* ↓ 50 *m*	A few fish rushed often for light, while the main group migrated slowly also for light.	Wavering of the main group continued.	The main group continued to stay in the light zone.
50 *m* ↓ 55 *m*	The main group stayed at the center of the tank, while a subordinate group formed in another place.	The same as above.	The main group went slowly to dissipate.
55 *m* ↓ 60 *m*	A main group settled in a less illuminated region, a few fish moving for light; but the latter returned to join in the main group.	The main group was formed in a darker place, swirling there slowly.	A new main group was formed again in a dim place.

contraction by itself. A few individuals of fish that separated from the main group swam about rather actively as compared with the members constituting the main group. They came very frequently in a heigh illumination zone.

As to the activity of fish motion there seemed to hold an order among the cases; Exp. I–1 > Exp. I–2 > Exp. 1–3, in the earlier half of first an hour; But this order was reversed in the later half. The data in this connection are shown in Tables 2, 3 and 4.

The strength of illumination in the section preferentially crowded by fish were found to be 21 *lux*, 4.4 *lux*, and 0.24 *lux* for Exp. I–1, Exp. I–2 and Exp. I–3, respectively. From such findings, it may be said that absolute value of illumination intensity does not govern the fish distribution, in agreement with KAWAMOTO.

Response of a fish group to illumination. In the preliminary experiment which was carried out at zero *lux* as above number of fish composing a group

Table 4. (Experiment I–3).

Section numbers	Illumination		Number of groups				Nnumber of fish in total			
	lux	lank	G	CT	CV	CA	F	CT	CV	CA
1	40	3	14	−9	5	11	104	−162	−58	34
2	50	3	1	−7	−6	0	3	−69	−66	26
3	45	3	12	−5	7	13	105	−41	64	156
4	20	3	3	−2	1	7	5	18	23	115
5	110	4	1	−2	−1	5	4	15	19	111
6	40	3	4	−9	−5	1	17	−109	−92	0
7	5	2	12	−7	5	11	91	−54	37	129
8	4.5	2	1	−2	−1	5	1	−6	−5	87
9	1.2	2	3	1	4	10	7	14	21	113
10	0.5	1	4	5	8	14	8	49	57	149
11	1.0	2	4	1	5	11	6	6	12	104
12	1.2	2	20	−7	13	19	136	−23	113	205
13	0.3	1	27	−2	25	31	490	−4	486	578
14	0.3	1	9	2	11	17	89	36	125	217
15	0.3	1	6	0	6	12	45	36	81	173
16	0.2	1	9	9	18	24	35	49	84	176
17	0.2	1	5	2	7	13	21	28	49	141
18	0.2	1	34	−1	33	39	454	13	467	559
19	0.2	1	26	6	32	38	359	23	382	474
20	0.2	1	6	14	20	26	13	52	65	157
21	0.2	1	13	7	20	26	37	43	80	172
22	0.2	1	20	2	22	28	105	30	135	227
23	0.2	1	8	6	14	20	33	42	75	167
24	0.2	1	25	−1	24	30	232	14	246	338
		Σ	267	0	267	511	2,400	0	2,400	4,608
		M	11.1		11.1	17.1	100		100	192

G: Number of groups (observed).
CT: Correction term.
CV: Corrected value.
CA: Corrected values adjusted for comparison.
F: Number of fish in total (observed).

was evaluated as 2.6 on the average.

The number of fish assembling at 0.2 *lux* into a group was calculated to be about 11 per group on the average. Though the number of fish constituting a group increased thus remarkably with increasing illumination from zero to 0.2 *lux*,

Table 5. (Experiment I-1).

Lux	Lank 1. (around 21 lux)			Lank 2. (around 48 lux)			Lank 3. (around 365 lux)			Lank 4. (around 960 lux)			Lank 5. (around 1300 lux)		
	lux	F	CA	lux	F	CA	lux	F	CA	lux	F	CA	lux	F	CA
	18	672	794	40	320	441	215	197	282	950	126	72	1300	1	44
	18	59	209	47	140	276	227	47	161	1000	26	93	1500	5	0
	19	79	217	40	37	181	380	25	147	950	17	143	4100	0	123
	21	63	214	58	165	309	500	3	105						
	22	19	179	53	179	283	500	22	76						
	25	128	259	49	32	189									
	26	38	195												
	Σ	1058	2067		873	1679		294	771		169	308		6	167
R.F.	%	44	41.4	%	36.3	33.6	%	1.22	15.4	%	7.0	6.1	%	0.5	3.5
R.A.	%	30			25			20		12.5				12.5	
A.F.		151	295		145	275		58	154		55	61		2	33

R.F.: Relative number of fish in a specified lank.
R.A.: Relative area of specified illumination.
A.F.: Average number of fish per section.

Table 6. (Experiment I-2).

Lux	Lank 1. (around 4.4 lux)			Lank 2. (around 19 lnx)			Lank 3. (around 77 lux)			Lank 4. (around 361 lux)			Lank 5. (around 950 lux)		
	lux	F	CA	lux	F	CA	lux	F	CA	lux	F	CA	lux	F	CA
	2.5	266	402	14	36	194	58	588	687	265	0	116	950	2	139
	2.5	52	216	11	198	356	64	28	156	225	18	86			
	2.5	110	262	20	687	805	110	16	152	500	2	15			
	4.5	3	168	32	14	185				370	8	148			
	4.5	17	191							350	38	119			
	3.0	109	254							450	10	63			
	8.0	134	269							370	40	0			
	7.5	6	156												
	4.5	18	189												
	Σ	715	2107		935	1540		630	995		116	547		2	137
R.F.	%	29.7	39.5	%	38.9	28.9	%	26.3	18.7	%	4.8	10.2	%	0.3	2.7
R.A.	%	38			17			13				29		3	
A.F.		79	234		233	385		210	331		16	78		2	137

R.F.: Relative number of fish in a specified lank.
R.A.: Relative area of specified illumination.
A.F.: Average number of fish per section.

the rate of increase was found to be leveled off gradually as the illumination becomes intensified (see Table 8). Since these experiments have been performed in complete absence of any baits, the fish behavior observed (see List A) may well be looked upon as that conducted purely by phototaxis of test fish. Tables 5, 6 and 7, are derived from Tables 2, 3 and 4, respectively.

Table 7. (Experiment I-3).

Lux	Lank 1. (around 0.24 lux)			Lank 2. (around 2.6 lux)			Lank 3. (around 39 lux)			Lank 4. (around 110 lux)		
	lux	F	CA	lux	F	CA	lux	F	CA	lux	F	CA
	0.2	232	338	1.2	136	205	40	17	0	110	4	111
	0.2	33	167	1.0	6	104	20	5	115			
	0.2	105	227	1.2	7	113	45	105	156			
	0.2	37	172	4.5	1	87	50	3	26			
	0.2	13	157	.5	91	129	40	104	34			
	0.2	359	474									
	0.2	454	559									
	0.2	21	141									
	0.2	35	176									
	0.3	45	173									
	0.3	89	217									
	0.3	490	578									
	0.5	8	149									
	Σ	1921	3528		241	638		234	331		4	111
R.F.	%	80	77	%	10	138	%	9.7	7.3	%	0.3	1.9
R.A.	%	54			20			20			6	
A.F.		147	271		48	127		46	66		4	111

R-F.: Relative number of fish in specified a lank.
R.A.: Relative area of specified illumination.
A.F.: Average number of fish per section.

Table 8.

Lux	Observed number of			Adjusted number of			Note
	group	fish	fish per group	group	fish	fish per group	
0.0	890	2400	2.6				Preliminary exp.
0.2	192	1921	10	318	3528	11	Exp. I-3
1.2	40	241	6	56	638	11.3	〃 3
4.5	94	715	7.6	201	2107	14.3	〃 2
17	67	935	13.9	99	1540	15.5	〃 2
21	93	1058	11.4	192	2067	10.8	〃 1
40	34	234	6.8	32	331	10.3	〃 3
48	81	873	10.8	134	1679	12.5	〃 1
64	33	632	19.1	49	995	20.3	〃 2
110	1	4	4	5	111	22.2	〃 3
320	32	116	3.6	40	547	13.6	〃 2
380	41	294	7.1	67	771	11.5	〃 1
950	43	169	3.9	33	308	9.3	〃 1
1400	3	6	2.0	21	44	2	〃 1
4100	0	0	0	6	123	20.5	〃 1

PART II. PREFERRENTIAL RESPONSE OF FISH TO THE ILLUMINATION FROM UNDERWATER LIGHT SOURCE

Following the above experiments made on the influence of an illumination from outside of the water upon the behavior of fish, it was examined this time the illumination effect due to an underwater light source.

Arrangement of experimental set

All things of this concern were the same as those in part I except that the lamp was set at the bottom of the tank as showen in Fig. 1. In this case, the mirror cup of the lamp gave rise to shadowed regions in two sections (sec-

Table 9. (Experiment II-1).

Section numbers	Illumination		Number of groups observed				Number of fish in total			
	lux	lank	G	CT	CV	CA	F	CT	CV	CA
1	24	2	21	−4.5		16.5	189	−81	108	140
1′	80	3	9	−4.5		4.5	81	−81	0	32
2	1200	6	7	−7		0	59	−69	−10	54
3	20	2	18	−2.5		15.5	210	−20.5	189.5	221.5
3′	60	3	13	−2.5		10.5	105	−20.5	84.5	116.5
4	150	2	6	−2		4	14	18	32	96
5	340	5	3	−2		1	8	15	23	87
6	110	4	10	−9		1	45	−109	−64	0
7	135	4	14	−7		7	68	−54	14	78
8	170	4	5	−2		3	36	−6	30	94
9	170	4	7	1		3	70	−14	84	148
10	55	3	13	4		17	72	49	121	185
11	90	3	4	1		5	14	6	20	84
12	70	3	24	−7		17	176	−23	153	217
13	35	2	18	−2		16	198	−4	194	258
14	35	2	4	2		6	38	36	74	138
15	35	2	12	0		12	31	36	67	131
16	21	2	5	9		14	16	49	65	129
17	25	2	4	2		6	13	28	41	105
18	25	2	25	−1		24	245	13	258	322
19	14.5	1	28	6		34	192	23	215	279
20	14.5	1	3	14		17	15	52	67	131
21	13.5	1	10	7		17	18	43	61	125
22	12	1	19	2		21	147	30	177	241
23	13.5	1	8	6		14	53	42	95	159
24	12	1	20	−1		19	287	14	301	365
		Σ	310	0		310	2400	0	2400	3936
		M	129			12.9	100		100	164

G: Number of groups (observed).
F: Number of fish in total (observed).
CT: Correction term.
CV: Corrected value.
CA: Corrected values adjusted for comparison.

tions 1′ and 3′ in the figure) producing two different illumination in each area of these sections.

Procedure of experiment

The procedure was just the same as that followed in the previous experiments (part I). Experiments II–1, II–2 and II–3 were carried out using illuminations gradating within the ranges of 1200～12 *lux*, 230～2.5 *lux* and 13.8～0.1 *lux*, respectively.

Result of experiment

Corrected values of experimental data are given in Table 1.

Table 10. (Experiment II–2).

Section numbers	Illumination		Number of groups				Number of fish in total			
	lux	lank	G	CT	CV	CA	F	CT	CV	CA
1	5.5	1	35	−4.5	30.5	31.5	406	−81	325	344
1′	100	4	12	−4.5	7.5	8.5	142	−81	61	80
2	230	5	16	−7	9	10	68	−69	−1	37
3	4.5	1	28	−2.5	25.5	26.5	194	−20	173	192
3′	45	3	10	−2.5	7.5	8.5	69	−21	49	68
4	45	3	8	−2	6	7	19	18	37	75
5	90	4	3	−2	1	2	10	15	25	63
6	45	3	13	−9	4	5	71	−109	−38	0
7	65	3	18	−7	11	12	103	−54	49	87
8	75	3	1	−2	−1	0	3	−6	−3	35
9	62	3	7	1	8	9	50	14	64	102
10	16.5	2	12	4	16	17	57	49	106	144
11	16	2	12	1	13	14	36	6	42	80
12	19.5	2	23	−7	16	17	157	−23	134	172
13	9.5	2	20	−2	18	19	70	−4	66	104
14	12	2	6	2	8	9	3	36	39	77
15	9.5	2	13	0	13	14	47	36	83	121
16	4.5	1	22	9	31	32	79	49	128	166
17	6	1	8	2	10	11	16	28	44	82
18	5.5	1	26	−1	25	26	119	13	132	170
19	3	1	35	6	41	42	202	23	225	263
20	4	1	5	14	19	20	9	52	61	99
21	3.5	1	20	7	27	28	72	43	115	153
22	2.5	1	32	2	34	35	128	30	158	196
23	3	1	13	6	19	20	43	42	85	123
24	2.5	1	29	−1	28	29	227	14	241	279
		Σ	427	0	427	453	2400	0	2400	3312
		M	17.8		17.8	18.8	100		100	138

G: Number of groups (observed).
F: Number of fish in total (observed).
CT: Correction term.
CV: Corrected value.
CA: Corrected values adjusted for comparison.

Behavior of fish. The behaviors of test fish observed are described in List B. The test fish were found in the main to assemble in a place of lower illumination similarly to the former experiments. More active swimming of fish was observed this time as compared with the former cases, while the motion was especially vivid in sections of higher illumination. A main group was observed as spontaneously repeating expansion and contraction. The present author considers that this circumstance is caused by a stimulative effect of illumination on the test fish. This effect proved to be intensified with increasing lux. (Fish distribution is expressed as the number of fish observed for each specified section at each time of observation just similarly to the former experiments).

Dependence of fish distribution upon illumination. Results of the present examination are summarized in Tables 9, 10 and 11, while Tables 12, 13 and 14

Table 11. (Experiment II-3).

Section numbers	Illumination		Number of groups				Number of fish in total			
	lux	lank	G	CT	CV	CA	F	CT	CV	CA
1	0.2	1	22	−4.5		17.5	163	−81	82	115.5
1′	1.0	2	19	−4.5		14.5	141	−81	60	93.5
2	13.5	5	14	−7		7	33	−69	−36	31
3	0.2	1	26	−2.5		23.5	188	−21	167	200.5
3′	1.0	2	13	−2.5		10.5	94	−20	74	107.5
4	3.5	3	13	−2		11	28	18	46	113
5	7	4	4	−2		2	14	15	29	96
6	1.0	2	17	−9		8	42	−109	−67	0
7	2	3	8	−7		1	35	−54	−19	48
8	3	3	2	−2		0	3	−6	−3	64
9	2	3	9	1		10	31	14	45	112
10	0.3	1	6	4		10	35	49	84	151
11	0.5	2	7	1		8	20	6	26	93
12	0.5	2	17	−7		10	57	−23	34	101
13	0.2	1	19	−2		17	101	−4	97	164
14	0.3	1	7	2		9	27	36	63	130
15	0.2	1	13	0		13	108	36	144	211
16	0.2	1	9	9		18	28	49	77	144
17	0.2	1	4	2		6	6	28	34	101
18	0.1	1	30	−1		29	137	13	150	217
19	0.1	1	37	6		43	258	23	281	348
20	0.1	1	11	14		52	45	52	97	164
21	0.1	1	18	7		25	65	43	108	175
22	0.1	1	30	2		32	199	30	229	296
23	0.1	1	19	6		25	68	42	110	177
24	0.1	1	46	−1		45	474	14	488	555
		Σ	420	0		420	2400	0	2400	4008
		M	17.5			17.5	100		100	167

G: Number of groups (observed).
F: Number of fish in total (observed).
CT: Correction term.
CV: Corrected value.
CA: Corrected values adjusted for comparison.

List B. Outlines of the behavior of test fish near an under-water light.

Time	Exp. II-1. 1200~12 *lux*	Exp. II-2. 230~2.5 *lux*	Exp. II. 13.5~0.1 *lux*
0 *m* ↓ 5 *m*	Fish scattered once and swum about randomly. They gathered at the center of the tank, forming a main group.	Fish scattered once and then moved for light.	Fish scattered once but gathered gradually into a group at the center of the tank.
5 *m* ↓ 10 *m*	The main group stayed near the light, but a few fish went soon into the shadows in sections No. 1′ and 3′, some rushing often into a lighter place.	Forming main group fish moved for light along the wall; they went meanwhile into the shadows in sections No. 1′ and 3′.	The main group separated into two groups: the one in a light place, the other in a dark place.
10 *m* ↓ 15 *m*	The same as above.	Fish remained in the shadowed zone.	The one group in the dark place moved for light along the wall but meanwhile it joined with the other, going to a shadowed.
15 *m* ↓ 20 *m*	Fish scattered, swimming vividly at random.	Two groups were formed, the one staying in a lighter and the other moving to a lower illumination place.	The main group was swirling along the wall, some members swimming counterwise to the rest.
20 *m* ↓ 25 *m*	Fish were swimming scattered.	The one group in the dim place migrated slowly to a lighter place. The group then joined in the other, the resultant group entering a shadowed zone.	The main group separated again into two groups, the one of which entering a shadowed place and the other swimming animatedly in a light place.
25 *m* ↓ 30 *m*	Fish formed anew a large group which moved for darkness.	The main group came back in a lighter zone and then returned to a darker zone.	One main group was formed in a darker region.
30 *m* ↓ 35 *m*	The main group became quiet in a lower illumination place. A few fish moved meantime into a lighter place.	The main group moved once more to a light zone and entered again a shadowed region.	The main group separated once more into two groups: The one in a light place, the other in a dark place.
35 *m* ↓ 40 *m*	The main group separated into two groups in a light place. The one went into a shadowed place, the other staying in the light place.	The main group remained in the shadow.	A main group was formed in a shadowed place.
40 *m* ↓ 45 *m*	Fish scattered, swimming at random.	One half of the group moved for light, the other also went into the lighter region.	The group settled in the shadow.
45 *m* ↓ 50 *m*	All the fish were observed swimming along the wall of tank.	Each fish swam about gently at random.	The main group was formed settling in a dim place.
50 *m* ↓ 55 *m*	Fish gathered in either shadows, forming two groups seen somewhat floating.	A main group was again formed in a dim place, fish moving calmly.	The same as above.
55 *m* ↓ 60 *m*	A main group was formed in a dim place with a few fish swimming in the light.	The main group settled in the dim place.	The same as above.

Table 12. (Experiment II-1).

Lux	Lank 1. (around 13.3 lux)			Lank 2. (around 31.6 lux)			Lank 3. (around 88.7 lux)			Lank 4. (around 147 lux)			Lank 5. (around 340 lux)		
	lux	F	CA	lux	F	CA	lux	F	CA	lux	F	CA	lux	F	CA
	12	287	365	25	245	322	70	176	217	170	70	148	340	8	87
	13.5	53	159	25	13	105	90	14	84	170	36	94			
	12	147	241	21	16	129	55	72	185	135	68	78	Lank 6. (1200 lux)		
	13.5	18	125	35	31	131	*60	105	116.5	110	45	0			
	14.5	15	131	35	38	138	*80	81	32	150	14	96	lux	D	C.D.
	14.5	192	279	35	198	258									
				*20	210	221.5							1200	59	54
				*25	189	140									
	Σ	712	1300	Σ	940	1444.5	Σ	448	634.5	Σ	233	416			
R.F.	%	29.6	33		39.1	36.7		18.2	161		9.7	105			
R.A.	%	25			29			17			20				
A.F.		118	216		134	206		112	158		29	83			

* Half section.
R.F.: Relative number of fish in a lank.
R.A.: Relative area of definite illumination.
A.F.: Average number of fish per section.

Table 13. (Experiment II-2).

Lux	Lank 1. (around 4.4 lux)			Lank 2. (around 13.8 lux)			Lank 3. (around 61.2 lux)			Lank 4. (around 93.5 lux)			Lank 5. (around 230 lux)		
	lux	F	CA	lux	F	CA	lux	F	CA	lux	F	CA	lux	F	CA
	2.5	227	279	9.5	47	121	62	50	102	90	10	63	230	68	37
	3.0	43	123	12	3	77	75	3	35	*100	142	80			
	2.5	128	196	9.5	70	104	65	103	87						
	3.5	72	153	19.5	157	172	45	71	0						
	4.0	9	99	16	36	80	45	19	75						
	3.0	202	263	16.5	57	144	*45	69	68						
	5.5	119	170												
	6.0	16	82												
	4.5	79	166												
	*5.5	406	344												
	*4.5	194	192												
	Σ	1495	2067	Σ	370	698	Σ	315	367	Σ	152	143	Σ	68	37
R.F.	%	62.2	62.4		15.4	21.1		13.1	11.1		6.3	4.4		3	1
R.A.	%	42			25			23			6			4	
A.F.		148	206		61	116		57	66		101	95		68	37

* Half section.
R.F.: Relative number of fish in a lank.
R.A.: Relative area of definite illumination.
A.F.: Average number of fish per section.

Table 14. (Experiment II-3).

Lux	Lank 1. (around 0.16 lux)			Lank 2. (around 0.83 lux)			Lank 3. (around 2.6 lux)			Lank 4. (around 7 lux)			Lank 5. (around 13.5 lux)		
	lux	F	CA	lux	F	CA	lux	F	CA	lux	F	CA	lux	F	CA
	0.1	478	555	0.5	57	101	2	31	112	7	14	96	13.5	33	31
	0.1	68	177	0.5	20	93	3	3	64						
	0.1	199	296	1	42	0	2	35	48						
	0.1	65	175	*1	94	107.5	3.5	28	113						
	0.1	45	164	*1	141	93.5									
	0.1	258	348												
	0.1	137	217												
	0.2	6	101												
	0.2	28	144												
	0.2	108	211												
	0.3	27	130												
	0.2	101	164												
	0.3	35	151												
	*0.2	163	115.5												
	*0.2	188	200.5												
	Σ	1902	3149	Σ	354	395	Σ	97	337	Σ	14	96	Σ	33	31
R.F.	%	79.2	78.5		14.7	9.8		4	8.4		0.7	2.3		1.4	1.0
R.A.	%	58			17			17			4			4	
A.F.		135	225		88	98		24	84		14	96		33	31

* Half section.
R.F.: Relative number of fish in a lank.
R.A.: Relative area of definite illumination.
A.F.: Average number of fish per section.

Table 15.

Lux	Observed number of			Adjusted number of			Note
	group	fish	fish per group	group	fish	fish per group	
0	890	2400	2.6				Preliminary exp.
0.16	297	1902	6.4	338	3149	9.3	Exp. II-3.
0.83	73	354	4.8	51	395	7.7	〃 3.
2.6	32	97	3.0	22	337	15.3	〃 3.
4.4	253	1495	5.9	301	2067	6.8	〃 2.
7	4	14	3.5	2	96	48.0	〃 3.
13.3	88	712	8.0	122	1300	10.6	〃 1.
13.5	14	33	2.3	7	31	4.4	〃 3.
13.8	86	370	4.3	90	698	7.7	〃 2.
31.6	113	940	8.3	114	1444.5	12.6	〃 1.
61.2	57	315	5.5	41.5	367	8.8	〃 2.
88.7	63	448	7.2	54	634.5	11.7	〃 1.
93.3	15	152	10.1	9.5	143	15.0	〃 2.
147	36	233	6.4	19	416	21.8	〃 1.
230	16	68	4.2	9	37	4.1	〃 2.
340	3	8	2.6	1	87	87.0	〃 1.
1200	7	59	8.4	0	54	?	〃 1.

have been led from the former ones, respectively. Almost the same distribution of fish are seen in the illumination lanks I and II of Exp. II–1. But the main group of fish in the lank I of Exp. II–2 or II–3 consists particularly of a large number of individuals. Such variety seems to be originated in the difference in absolute strength of the illumination applied. It is also worthy notice that not a small fraction of test fish gathered in the shadowed quarters provided by the cup of lamp. The situation that the increase of fish individuals composing a main group tended gradually to a plateau as the illumination was raised is quite similar to the situation found in the previous experiments (See Table 15).

Conclusion involing Parts I and II

1. Fish are more active in their motion in the presence of an under-water-light than under a normal light, i.e., an illumination from the outside.

2. In fishery, the estimation of fish phototaxis has beed referred to the count of such fish that come actually into appearance in an illuminated region of water. From the result of the above experiments, however, it may naturally be inferred that a more or less serious portion of fish swimming about that region are always out of sight for fishermen.

3. It seems likely that, while the group of fish formed in a zone of high light looks as if quite fixed, members in the group in fact are being alternated by some external ones in a steady manner. The fish that are just now seeking any baits will stay in such a zone fairly for a long time.

4. In gathering any fish, it seems very effective to provide shadowed zones within a high illumination; shadows and dim spaces will serve for fishes as comfortable places for rest.

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INVESTIGATION ON THE SOURCE AND AREA OF CONTAMINATION IN TOKYO BAY (Vertical Survey)

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Introduction

At the previous survey (1955)[1], we investigated on the faecal pollution of surface water and representative fisheries resources (shell-fish and *Asakusa-nori*) of Tokyo Bay influenced by extreme development of surrounding cities and factories on the bacteriological point of view.

Successively in order to obtain the more wide knowledge about actual state, we practiced the survey from June to September 1956 as following procedure, and observed on its vertical pollution.

As we were restricted with the schedule of observation boat, this survey was carried out within the area north of Kanazawa-Futs line.

Procedure of Survey

22 sampling stations were selected along the coast and in the central area of the bay as regarding to the results of previous survey. The water was collected by sampling bottle at each layer of surface, 3 m., 5 m., 10 m. and 20 m. depth. Bottom deposits were collected by snapper type bottom sampler and immediately put into sterilized glass tubes. These samples were preserved in the cold box cooling by dry ice at 8–11°C, for about 1–5 hours on our way to laboratory. And then, they were examined by cultural and chemical tests in accordance with the method of Hygienic examination guide[2,3]. The cultural test were performed on colony counts, and M. P. N. of Coli forms and Enterococci. As to the classification of Coli form group they were specified into 3 types (Escherichia, Aerobacter and Intermediate) by means of IMVIC system and calculated each detectin rate. For the chemical test of sea water, we practiced qualitative analyses of ammonia–N and nitrite–N. Additionary the water temperature, specific gravity and pH were observed.

Results and Consideration

The results of this survey are presented in table 1–2 and fig. 1–6. There were few rainy days during one week before the beginning of survey, therefore, results were not influenced by any rainfall effect.[4].

From the results of this survey, it is difficult to reach the definite conclusion, however at least, we might be able to say as follows.

1) *On the mutual relation between colony counts and M. P. N. of Coli forms and Enterococci.*

Table 1.

St.	Layer	Colony counts /cc.	Coli forms M.P.N. /100cc.	IMVIC E	IMVIC A	IMVIC I	Entero M.P.N.	NO_2–N	NH_3–N	Water depth	Bottom character
A	0	20,000	330	+	+	+	130	++	±	3.8	M
	3	2,000	210	+	+	+	45	++	++		
	b	100,000	400	−	−	−	340				
B	0	10,000	270	+	+	+	−	++	+	10.0	M
	3	2,000	45	+	−	−	−	++	+		
	5	1,000	120	−	+	+	−	++	++		
	b	100,000	800	−	−	−	90				
C	0	10,000	78	−	+	−	−	+	+	9.5	M
	3	2,000	−				−	+	+		
	b	350,000	360	−	+	−	1,900				
D	0	10,000	45	−	+	+	−	±	+	20.0	SM
	3	5,000	80	−	+	+	−	±	+		
	5	400	78	+	−	+	10	±	+		
	10	60	45	−	+	+	−	−	++		
	b	400,000	48,000	−	−	+	−				
E	0	4,000	78	−	+	+	−	−	±	17.0	M
	3	2,000	100	−	+	+	−	±	±		
	5	600	78	−	−	+	−	±	±		
	10	150	130	−	+	+	−	±	−		
	b	70,000	54,000	−	−	+	−				
F	0	4,000	20	−	−	+	−	−	+	19.0	SM
	3	800	−				−	−	+		
	5	200	−				−	−	+		
	10	60	40	−	+	−	−	−	+		
	b	150,000	3,400	−	−	+	−				
G	0	2,000	−				−	±	+	13.0	M
	3	1,000	60	−	−	+	−	±	+		
	5	200	78	−	−	+	−	+	+		
	10	300	78	+	−	+	−	+	+		
	b	200,000	2,200	+	−	−	−				
H	0	30,000	4,300	+	+	+	−	+	+++	6.0	M
	5	1,000	2,400	+	+	−	165	++	++		
	b	300,000	15,800	−	+	+	1,120				
J	0	640	−				45	±	+	6.0	M
	3	160	−				−	±	+		
	5	100	−				40	±	+		
	b	70,000	−				−				
K	0	250	−				−	−	±	8.0	M
	3	300	−				−	±	+		
	5	240	−				−	±	+		
	b	3,000	−				−				
L	0	1,200	−				−	+	±	7.0	M
	3	1,200	−				−	±	±		
	5	240	−				−	±	−		
	b	5,000	2,000				2,000				
M	0	120	−	−	−	−	−	±	−	7.0	M
	3	30	20	−	−	−	−	±	±		
	5	20,000	−	−	−	−	−	±	±		
	10	1,000	−	−	−	−	−	+	+		
	b	22,000	2,000	−	+	+	−				

Continued from Table 1.

St.	Layer	Colony counts /cc.	Coli forms M.P.N. /100cc	IMVIC E	IMVIC A	IMVIC I	Entero M.P.N.	NO_2-N	NH_3-N	Water depth	Bottom character
N	0	60	−	−	−	−	−	+	+	12.0	M
	5	360	−	−	−	−	−	+	+		
	10	25	−	−	−	−	−	+	+		
	b	20,000	2,000	−	+	−	−				
O	0	150	−	−	−	−	78	+	±	6.5	M
	3	150	20	−	−	−	−	−	+		
	5	700	−	−	−	−	−	−	±		
	b	15,000	2,000	−	+	−					
P	0	720	23	−	−	−	4	±	±	18.0	S. Sh.
	3	1,100	110	−	+	+	17	±	±		
	5	1,200	64	−	+	+	14	±	±		
	10	5,400	22	−	+	+	−	±	±		
	b	8,100	5,600	−	−	+	156				
Q	0	86	4	−	−	−	4	±	+	17.0	S. Sh.
	3	8	13	+	−	−	2	±	+		
	5	840	11	−	+	+	4	−	±		
	10	200	13	+	+	−	4	±	+		
	b	1,600	800	−	−	±	−				
R	0	68	−	−	−	−	−	±	+	7.0	S. Sh.
	3	10	13	−	+	−	−	−	+		
	5	480	17	+	+	+	4	±	+		
	b	2,700	18,400	+	−	+	386				
S	0	360	−	−	−	−	−	++	±	25.0	SM
	3	2	4	−	+	+	2	±	+		
	5	360	13	−	+	+	2	±	+		
	10	220	140	−	+	−	4	±	+		
	b	1,600	4,500	−	−	−	−				
T	0	120	−	−	−	−	2	±	±	33.0	MS
	3	17	130	−	−	+	15	−	±		
	5	360	25	−	+	−	15	−	±		
	10	140	6	−	+	+	23	±	±		
	20	360	46	−	−	+	4	±	+		
	b	inf.	70,000	−	+	−	−				
U	0	120	11	−	−	−	8	±	±	26.0	MS
	3	110	23	−	+	−	4	−	±		
	5	1,800	79	−	+	+	6	−	±		
	10	2,200	79	−	+	−	2	±	+		
	20	62	27	−	+	−	12	±	±		
	b	inf.	350,000	−	+	−	4,000				
V	0	200	−	−	−	−	10	+	±	10.0	M
	3	150	−	−	−	−	−	+	−		
	5	120	−	−	−	−	−	−	−		
	b	10,000	2,000	−	+	+	−				
W	0	50	−	−	−	−	−	−	−	18.0	M
	3	20	−	−	−	−	−	−	−		
	5	30	−	−	−	−	−	−	−		
	b	4,500	3,500	−	+	−	−				

Table 2.

St.	Layer	Water temp. °C	Speci. gravity	pH	St.	Lev. m.	Water temp. C°	Speci. gravity	pH
A	0	23.1	16.1	6.7	N	0	29.6	18.3	6.6
	3	21.6	23.5	6.6		3	—	—	—
	0	23.1	19.7	6.6		5	27.8	19.1	6.8
B	3	22.5	18.2	6.7		10	23.7	23.0	6.8
	5	21.4	20.3	6.8	O	0	30.7	18.1	6.6
C	0	23.0	15.1	6.7		3	28.8	19.5	7.0
	3	22.4	17.2	6.7		5	28.6	19.7	6.8
D	0	22.0	—	6.8	P	0	26.2	19.2	6.4
	3	22.8	—	6.8		3	24.8	19.5	7.0
	5	22.8	—	6.8		5	23,8	20.5	7.2
	10	21.7	—	6.7		10	21.2	22.0	7.0
E	0	21.6	—	6.9	Q	0	26.1	19.5	7.4
	3	21.6	—	6.7		3	22.7	21.0	7.2
	5	21.6	—	6.7		5	23.6	22.0	7.2
	10	21.5	—	6.9		10	21.6	22.3	7.4
F	0	19.9	—	6.6	R	0	25.3	19.5	7.0
	3	20.0	—	6.6		3	22.4	22.0	7.0
	5	22.1	—	6.6		5	21.8	22.3	7.2
	10	22.0	—	6.7		0	26.8	19.5	7.2
G	0	21.4	—	6.7	S	3	22.2	22.0	7.2
	3	21.4	—	6.7		5	22.4	22.4	7.4
	5	21.4	—	6.7		10	21.2	22.5	7.4
	10	21.3	—	6.6	T	0	27.1	19.5	7.0
H	0	23.6	—	6.6		3	23.5	20.1	7.2
	5	23.0	—	6.6		5	22.9	21.0	7.2
						10	22.1	22.0	7.2
J	0	28.9	18.1	6.6		20	20.9	22.7	7.4
	3	27.1	19.1	6.6	U	0	27.5	16.7	7.4
	5	27.8	22.2	6.4		3	26.7	17.2	6.8
K	0	29.2	17.5	6.6		5	25.8	17.7	7.0
	3	28.3	18.0	6.8		10	23.2	21.0	7.0
	5	28.0	18.5	6.8		20	20.4	23.0	7.0
L	0	28.9	18.0	6.8	V	0	29.1	18.7	6.8
	3	27.1	19.4	6.8		3	28.8	19.1	7.0
	5	27.8	22.3	6.5		5	28.6	19.5	7.0
M	0	29.2	15.5	6.8	W	0	27.0	19.5	7.0
	3	28.4	18.2	7.0		3	24.2	22.0	7.2
	5	28.4	18.2	6.8		5	22.4	22.4	7.2
	10	22.5	23.4	6.8					

At the area showing distinct colony counts, there are also high M. P. N. values, but it is obvious that colony counts have essentialy no quantitative relation with M. P. N. of these indicator organisms for pollution.[4].

Past investigation by Ritsky *et al.* (1955) have indicated the corelation of +0.84 between the numbers of E. coli and Enterococci in river water. And also showed there are straight line equation $y=0.98+0.95x$.[5] However, we obtained the corelation of +0.09 from these data. Therefore we could not find any close relationship among them.

2) *On the relation between depth and numbers on bacteria.*

Sewage containing abundant of microorganisms flow into the bay, and

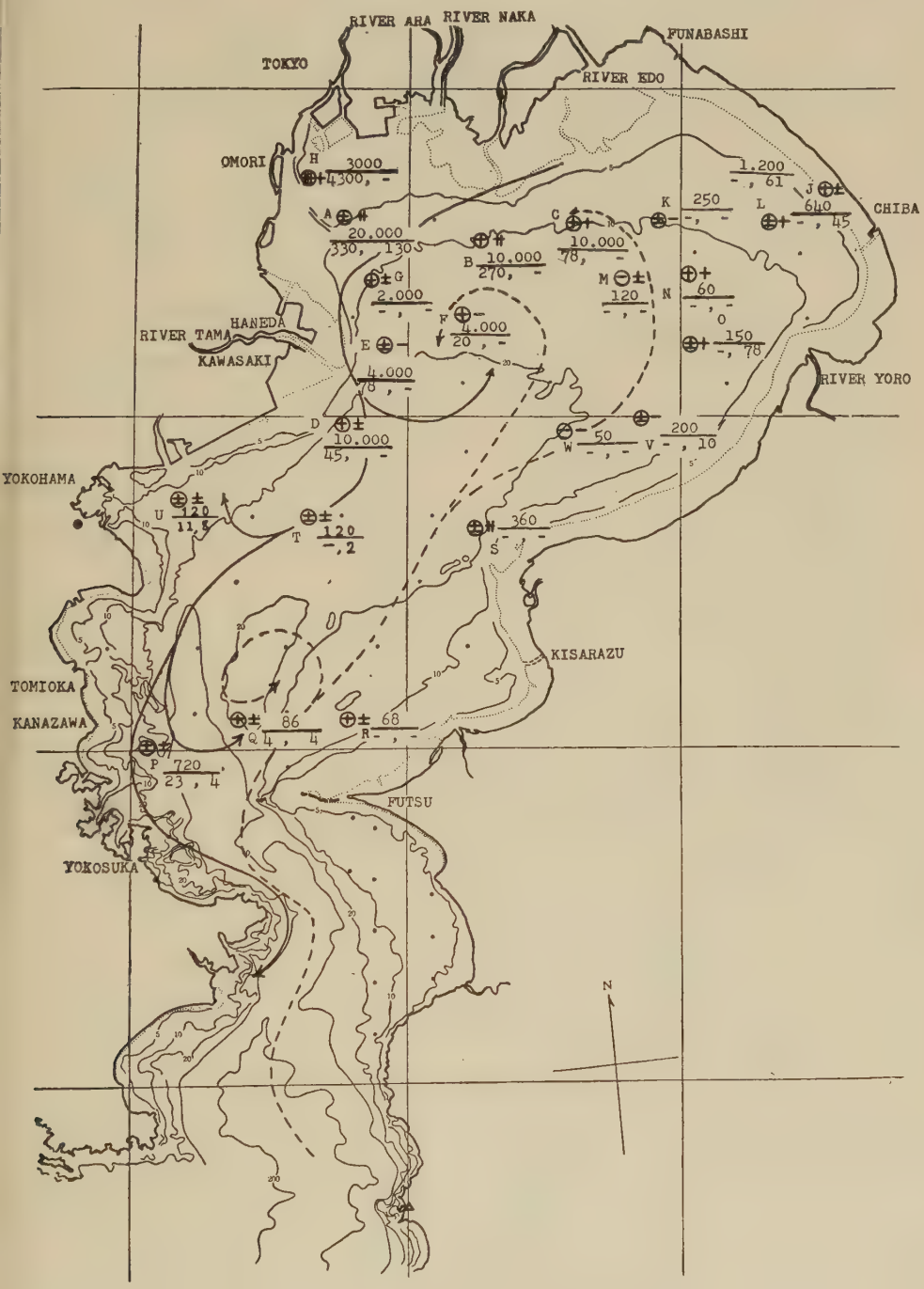

Fig. 1. Colony counts and M. P. N. of Coli forms and Enterococci (Surface)

$$\frac{\text{colony counts}}{\text{Coli forms M. P. N. Enterococci M. P. N.}} \quad \oplus- \begin{cases} \text{ammonia-N (left-side)} \\ \text{nitrite-N (right-side)} \end{cases}$$

----→ oceanic water, ⟶ coastal water

Fig. 2. 3 meters layer.

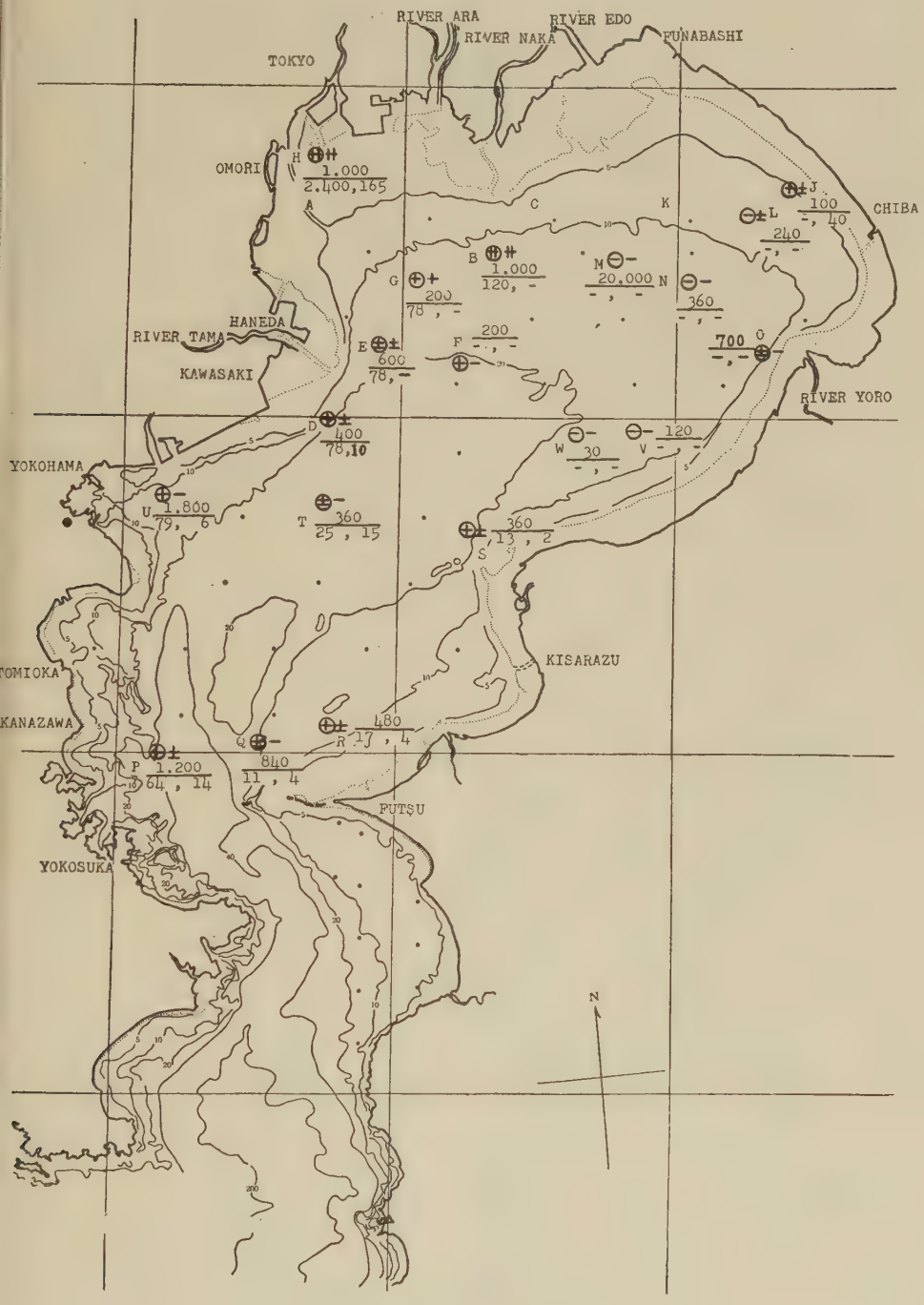

Fig. 3. 5 meters layer.

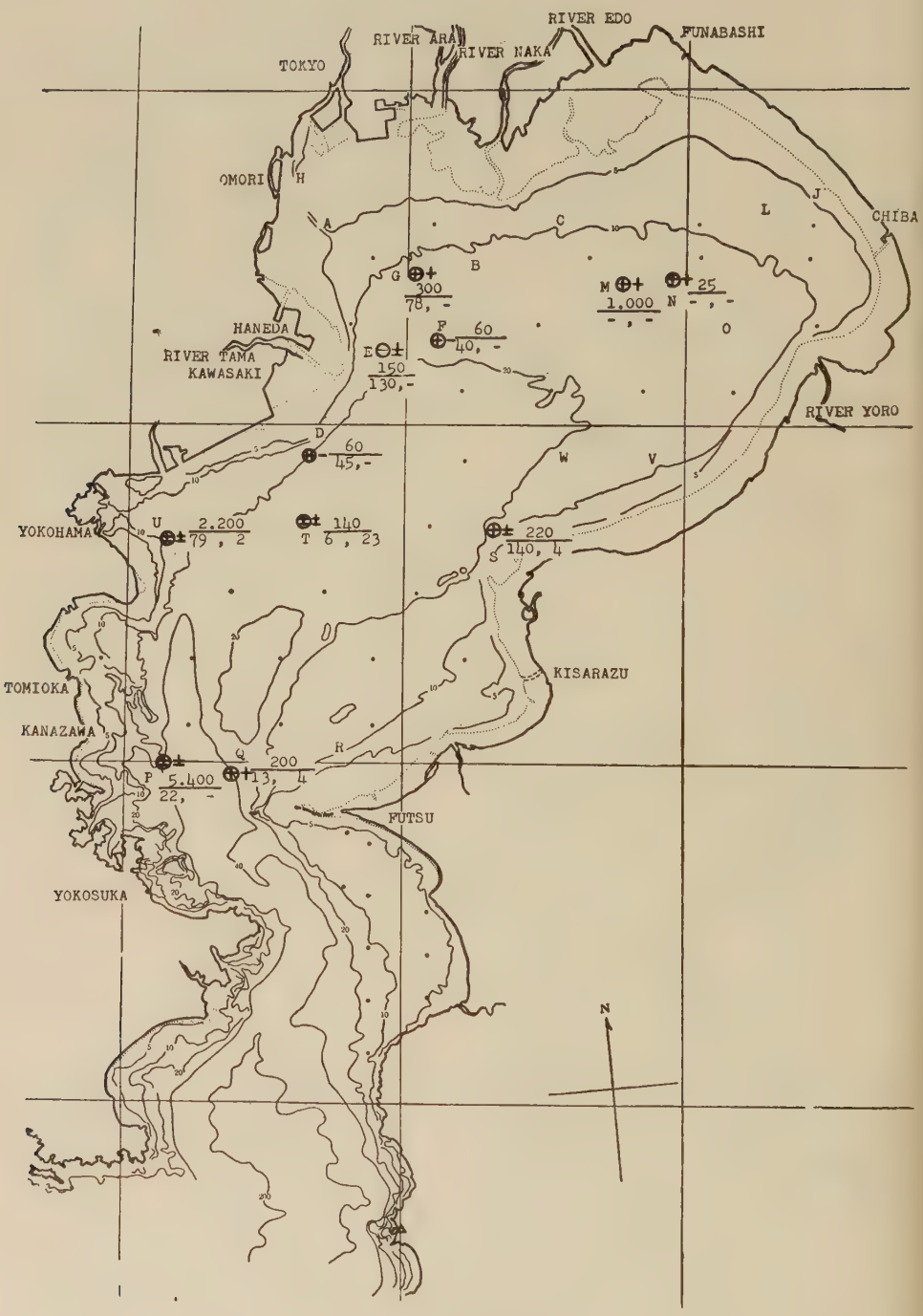

Fig. 4. 10 meters layer.

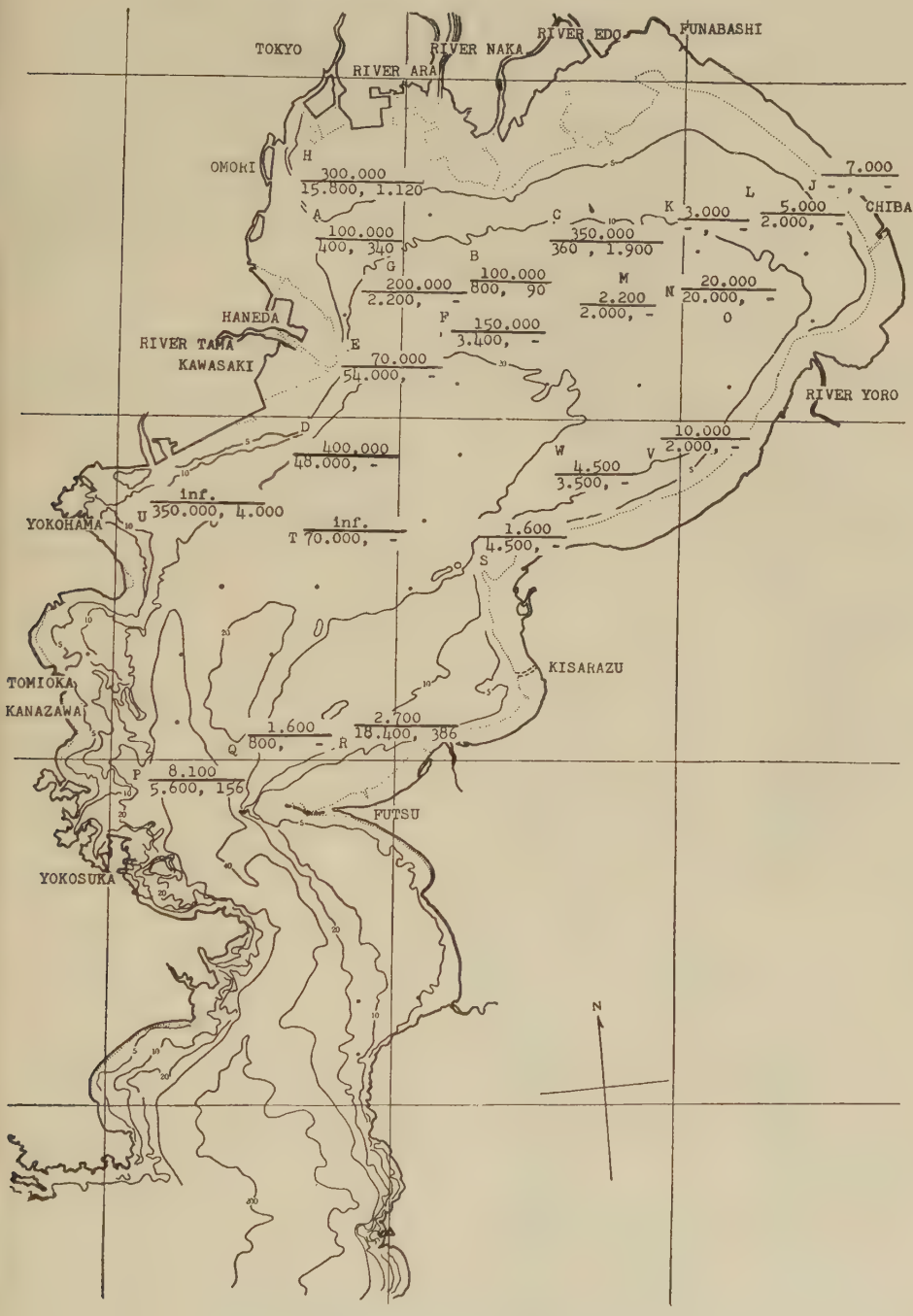

Fig. 5. Bottom deposits.

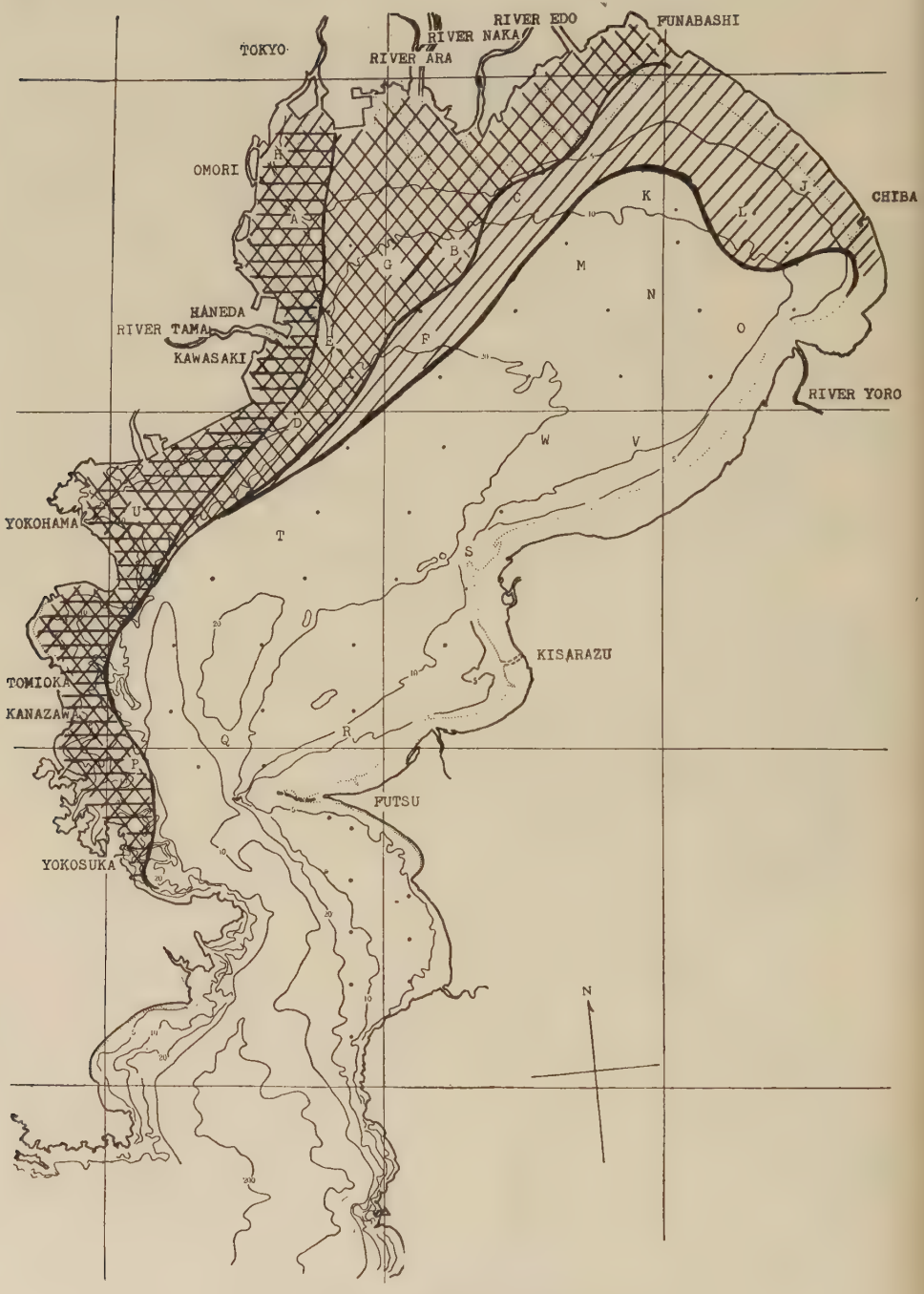

Fig. 6. Summarized map of contaminated area

///// colony counts over 1.000
XXXX coli forms M. P. N. over 50
VVVV enterococci M. P. N. over 10

gradually diffused at first occupying over the surface layer due to its low specific gravity. Consequently, the maximum bacterial numbers are shown in surface near shore water. Then they precipitate towards the bottom with debris which they adhere to.

Usually, the death rate of intestinal bacteria increases in sea water and they will be soon perished.

One of the most important factor is the vertical mixing due to wave motion and turbulence developed by tidal current in relatively shallow sea area. At the same time we may be able to estimate the upward moving water set up near the bottom—up-welling or counter current[6]—in the district where the fresh water contact with high saline water.

At the station A–L, V–W it was observed the tendency decreasing bacterial numbers as the increase of water depth, that is normal distribution. At the station M–U, P–R, however, there were observed the spring layers and inverse distribution.

The mixing coastal water and oceanic water in Tokyo bay, though there is periodic change mainly influenced by tidal movement, usually take place at the north-east 2–3 miles off Yokosuka and about 7–8 miles east off Haneda forming circulation.[7,8]

Consequently these area, we might be able to estimate the abnormal distribution of bacteria.

3) *On the extreme density of bacteria in bottom deposits.*

There are observed great many bacterial numbers in bottom deposits from 10 to 100 times as large as those in sea water. The adsorption effect of muddy deposits for the bacterial organisms may give reasonable explanation in a sense.[9] At the same time, it may be not so difficult to estimate the secondary multiplication of bacteria in suitable envelopment forming by bottom deposits containing abundant organic substances. But it should be required for further study in future.

4) *Ammonia–N, nitrite–N and bacterial numbers.*

It was observed direct relation between bacterial numbers and positive of ammonia–N and nitrite–N decomposed from organic substances.

5) *Composition and detecting ratio of Coli forms and Enterococci in each layer of sea water and bottom deposits.*

Following table was calculated on 95 samples excepting 2 bottoles broken and the same of 20 m. depth layer.

i) Coli forms give the positive ratio of 91% in bottom deposits and of over 45% in sea water. The results of classification into 3 types showed both Aerobacter and Intermediate 39% and E. coli was only 14%. Aerobacter and Intermediate are predominant group in sea water and bottom deposits in contrast with detecting in the faeces of human and warm-blooded animals. (Table 4)

ii) The positive ratio of Enterococci in sea water showed maximum 45% in 5 m. layer and minimum 30% in 3 m. layer. Bottom deposits were 32%.

Table 3.

Water depth m.	Number of samples	Coli forms				Entero.
		Positive number of samples Detecting ratio (%)				
		Total	E. coli	Aero.	Inter	
0	22	10 45%	3 14%	6 27%	6 27%	9 41%
3	20	13 65%	2 10%	6 30%	7 35%	6 30%
5	20	11 55%	4 20%	8 40%	9 45%	9 45%
10	11	9 82%	2 18%	8 73%	5 45%	4 36%
b	22	20 91%	2 9%	9 41%	10 46%	7 32%
Total	95	63 65%	13 14%	37 39%	37 39%	35 37%

Table 4. *Composition of Coli forms detected from the faeces of human and warm blooded animales*
(after Sekine 1955)

Number of samples	E. coli	Aerobacter	Intermediate
116	77	12	8
	66%	10%	7%

6) *Horizontal distribution of microorganisms.*

From the general view of fig. 1–6, we may be able to summarize as follows.

i) The area of over 10^3 of colony counts is shown with about 3 miles width from off Chiba city along the north coast, extending off River Edo estuary to rather southwards, then along the west coast with 3 miles width to Yokosuka.

ii) The area where M. P. N. of Coil forms were over 50 is shown with the same width from Funabashi to Yokosuka.

iii) The area where M. P. N. of Enterococci were over 10 is adjacent to the coast line from River Sumida estuary to Yokosuka.

Summary

In either case, these results showed gross contamination along the west coast through each layer, consistently with previous survey.

Acknowledgements

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T. Kojima and members of the Chiba fisheries experimenting station offering suitable advices and convenience.

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ENRICHMENT PATTERN RESULTING FROM EDDY SYSTEMS IN RELATION TO FISHING GROUNDS

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Introduction

Concerning the basic productivity of the fishing grounds or fishing localities, we have hitherto obtained many oceanographical factors such as optimum temperature, optimum water mass, (including fertility of water masses), favourable submarine illumination or turbidity, favourable currents (upwelling, thermo-anticline or ridging, thermocline, convergence and divergence, cascading, turbulent mixing by waves and current, vertical flow, dispersal, horizontal transport), wind conditions, plankton blooming, biomass, etc.

In addition to them eddy currents in counter-clock-wise (or cyclonic) gyral around a cold core in northern hemisphere) and eddy currents in clockwise (or anticyclonic gyral around a warm core in the northern hemisphere) have important meaning for the marine productivity and consequently have intimate relation to the fishing grounds.

The undulated patterns of oceanic fronts due to shearing instability caused by the velocity difference on both sides of fronts development in eddies. On the line of convergence designated by current-rips and slicks on the sea-surface we can find the sinking of water masses and accumulation of dusts, drifting substances and some living organisms including planktons, fishes and whales etc, showing some biological line of demarkation usually[1]. The line of divergence mainly along the coastal region of continents or islands or near the oceanic banks, caused by the prevailing offshore current or offshore wind and sometimes caused by the collision of undercurrent to the bank or shelf, corresponds always to the zone of upwelling representing the area of rich nutrient salts and consequently plenty of marine life already found by the Meteor Survey (A. Defant, 1930, 1931)[2] or recently by the Calif. Cooper. Ocean. Fish. Invest. 1950–'56)[3]. The fine structure of oceanic front has been developed by many authors (M. Uda 1938)[1] T. Cromwell and Joe Reid, Jr. (1956) of SIO[4] mainly on the fronts along the Equatorial Counter-Current and by many oceanographers of Woods Hole Oceanogr. Institution. e. g. C'od Iselin[5], F. C. Fuglister[6], Worthington[7], W. L. Ford and A. R. Miller[8], H. Stommel[9], Haurwitz and Panovsky[10] Von Arx etc.[11] (1950–'57) on the edge of the Gulf Stream with the adjacent cold belt and warm core, meander and the shingle structure of Gulf Stream. Recently by many Japanese oceanographers the researches on the structure of Oyasio Front and Kurosio front were developed e. g. H. Kawai[12], J. Masuzawa[13], T. Ichiye[14] D. Shōji[15][19] M. Koizumi[16], J. Fukuoka[17], J. Sugiura[18], S. Hayami[20], M. Uda[21]. etc. and some of them[14] discussed the eddy development by applying the theory of perturbation theoretically.

I. Three types of eddy-systems

Compiling recent studies in relation to the commercial fishing grounds, one of the authors (M. UDA) classified the enrichment pattern resulting from eddy-systems into the following three types:

(1) Dynamical eddy system.

The collision of two different current-systems e. g. cold and warm current or the currents belonging to the oceanic water and coastal water represent oceanic front dynamically, which shifts to and fro according to the prevalence of the current on each side alternatively.

For example, if we compare the isotherms in the upper layer (at the depths of 10, 50 and 100 m.) of the North Pacific Ocean obtained by the NORPAC PROJECT during the summer of 1955 to the fishing grounds of important pelagic fishes (skipjack, albacore, bluefin-tuna, salmon, squid, pacific saury and whales) in the same summer season, we can point out the most favourable fishing grounds or in other words the most productive zone lying almost incoincidence to the eddies associated with oceanic frontal zone. (Fig. 1 a, b, c). In particular, the cold patches at the center of the cyclonic eddy lying near the southernmost top of the cold current correspond to the most concentrated localities of pacific

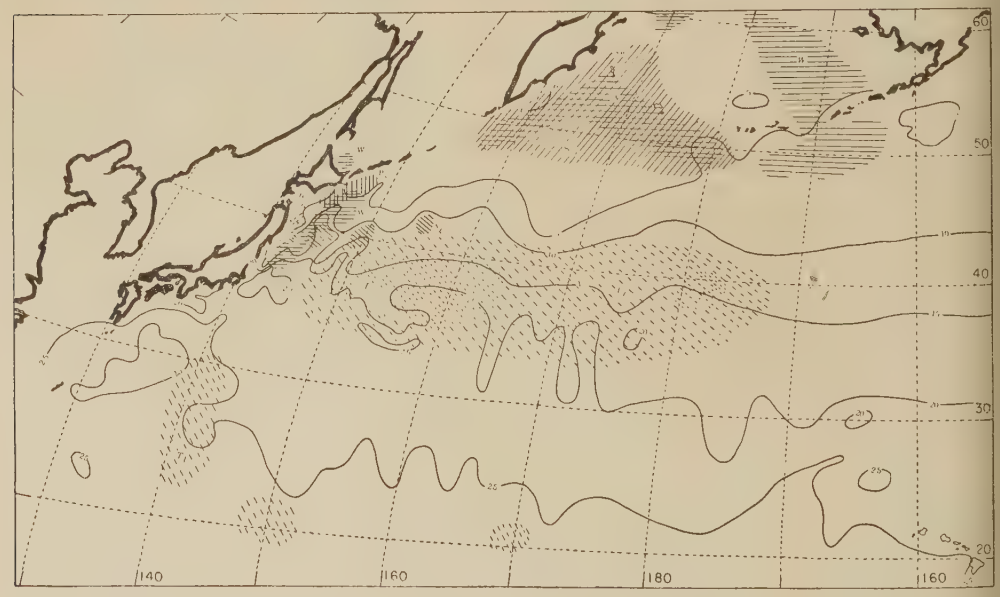


Fig. 1a. Water temp. at the depth of 50 m. and the fishing grounds in the North Pacific during the summer of 1955.

—: Isotherms (°C)
W: Whaling ground
Ps: Pacific saury fishing ground
Bl: Bulefin tuna 〃 〃
Sk: Skipjack fishing ground
Sal: Salmon & Trout 〃 〃
Tl: Longline tuna 〃 〃 (Albacore etc.)

Fig. 1b. Distribution of water temp. at the depth of 50 m. (°C) and the fishing grounds in the waters adjacent to Japan during the mid-summer of 1955.
F: Fin whale ||| S: Sei whale /// Sk: Skipjack ≡
M: Mackerel ⁘ Sp: Sperm 〃 ⁘ Bl: Bluefin tuna ///

Fig. 1c. Whaling grounds and current in the waters adj. to Japan. (Hatched area shows the whaling grounds)

saury, in autumn, whales (fin whale, sperm whale etc) and albacore in spring and early summer. (M. UDA 1937, 1954)[32)34)] (Fig. 2 a, b, c).

On the contrary, the warm core showing anticyclonic eddy (especially of pocket-in type of warm water mass) lying near the top of the warm current corresponds to the dense fishing localities of skipjack, sei-whale and albacore in

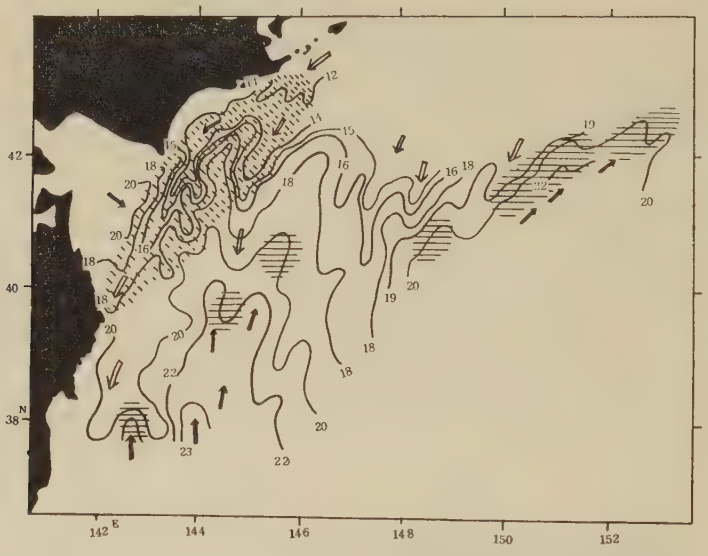


Fig. 2a Isotherms of surface water temperature and fishing grounds during 16–20. Sept. 1957.

Surface water temp. (°C), Pacific saury fishing ground (▨) and Skipjack fishing ground (≡) on 16–20, Sept., 1957

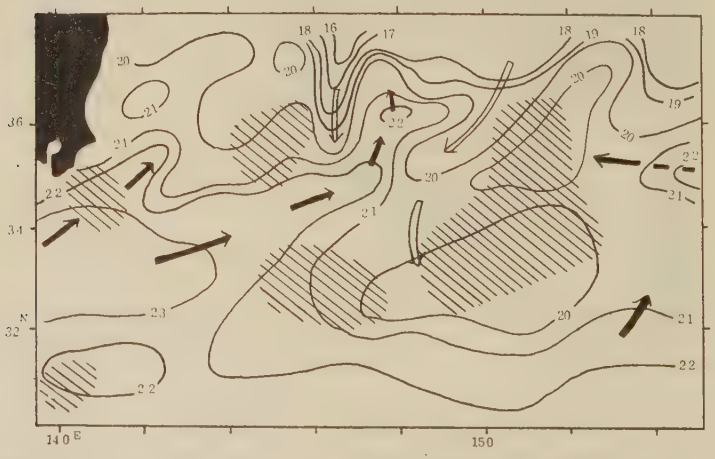


Fig. 2b. Surface temperature (°C) and albacore fishing grounds (▨) in middle-June 1957.

the midsummer. (Fig. 2b). In Fig. 2c, we can notice the pecular location of each fishing grounds around a quasistationary eddy. It appears that the migrating fishes stay in the eddies and move quickly between the eddies, intermingling and interchanging of fish-shoals in the consecutive eddies as its consequence.

The dynamical eddies along the polar front including both Oyasio Front and Kurosio Front show the cold occluded or warm occluded front type as the north-going (from early spring to mid-summer) or south-going (from late summer to winter) shift of the general pattern in accompany with the fluctuation of cold and warm currents, and also in addition to them the stationary front type as the intermediate one from mid-summer to late summer.

Fig. 2c. Fishing grounds and currents in the offing of Kii Peninsula (May-June, 1937–'41)

F: Boundary of water-mass (ca 20°C)
Co: Coastal current
K: Kurosio
C: Cold water (core) (Ca 16°C)
⁂B: Bluefin tuna fishing ground
×A: Albacore fishing ground
⩩Sk: Skipjack fishing ground

The profiles of water temperature in the Northwestern Pacific obtained by Norpac Project indicate clearly the coupling of the cold (upwelling) and warm (sinking) water masses in those eddies along the front and the most favourable fishing grounds in relation to them. Each localities of cold and warm occuluded water masses on the above eddies correspond to the important fishing grounds respectively and therefore to the enrichment patterns which show some quasi-stationary distribution and consequently fluctuate around the average position month by month or year by year. The degree of enrichment seems to be proportional to the amount of vorticity concerning to each eddies and generally to the convergency of the polar front or roughly to the temperature gradient of the water masses on both sides of the front. Concerning the above-mentioned, the authors ascertained them by means of some model experiment in water tank and by the results of oceanographic observations in the actual seas and oceans during long years. (M. Uda (1930–1957).

(2) The topographical (or orogrophic) eddy system.

By means of so many oceanographical surveys and fisheries exploitations, we have already studied the eddy systems caused by the irregularities of topography (elevation, depression, configuration, size and depth of islands, banks, strait, bays etc.) which represent the local fishing grounds associated with those eddies.

In order to discover the mechanism of those local enrichment patterns produced by the peculiar topographical features the authors have studied by means of model experiments undertaken in the water tank at the Tateyama Laboratory belonging to the Tokyo University of Fisheries during 1952–'54.

Aluminium powder and fine sand (in addition to them sometimes used the potassium permanganate solution of violet tint) were used to indicate the stream pattern.

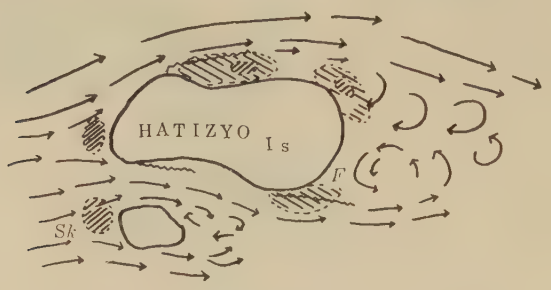


Fig. 3. Schematic chart of currents and fishing grounds aronud Hatizyō Is.
F ⩩: Flying-fish fishing ground
Sk ///: Skipjack " "

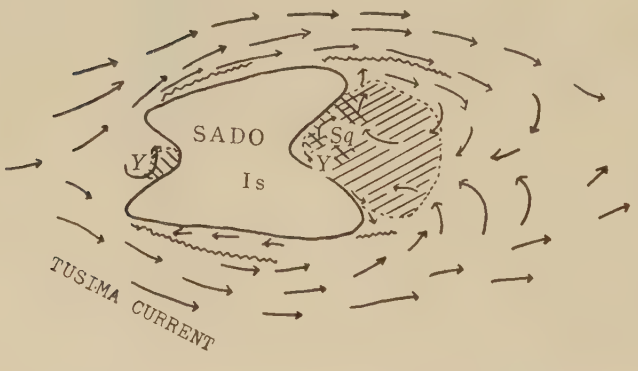


Fig. 4. Schematic chart of currents and fishing grounds around Sado Is.
///Sq: Squid fishing ground
⩩Y: Yellow-tail " "

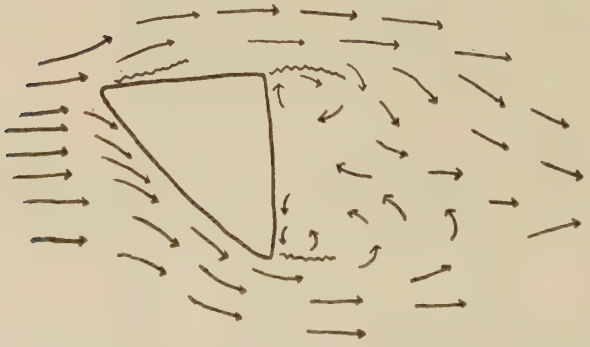


Fig. 5. Schematic chart of currents around a triangular model.

A. Experiments by means of the model on flat bottom.

The remarkable results of our experiments in reference to the actual flow fishing ground are shown as follow:

(i) Typical flow pattern around the model of Hatizyō Island.

(Photo. 1, Fig. 3). Refer to B. (i), (ii), (iii). Fishing grounds of flying-fish and skipjack fall in eddies.

(ii) Typical flow pattern around the simple model of Sado Island.

(Photo 2a, b, Fig. 4). With respect to the exact model, refer to B. (iv). Fishing grounds of yellowtail and squid fall in eddies.

(iii) Typical flow pattern around a triangular model. This corresponds to the case of fishing grounds near a cape or a peninsula.

(Photo 3 and Fig. 5).

(iv) Typical flow pattern around a circular model alike to Idu-Ōsima Is.

(Photo. 4a, b, Fig.

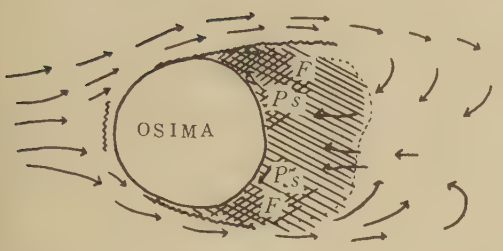
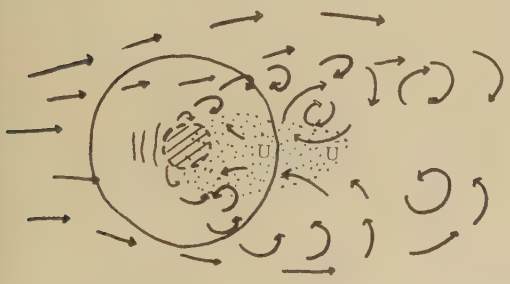


Fig. 6. Schematic chart of currents and fishing grounds around Idu-Ōsima Is.
F: Flying-fish fishing ground
Ps: Pacific Saury 〃 〃



U: Upwelling

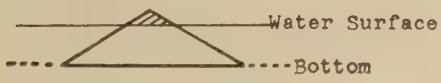
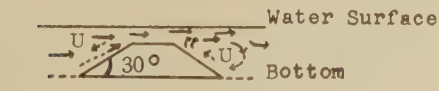


Fig. 7. Schematic chart of currents around a sloped island or a cone reef. (base 23 cm, water depth 8 cm, V_0=17 cm/s, ht. of cone 9 cm.).



U: Upwelling

Fig. 8. Schematic chart of currents around a submarine bank. (top. dia. 5 cm, water depth 2.6 cm, bottom depth 7.9 cm. V_0=17 cm/s.).

6). Fishing grounds of pacific saury and flying-fish correspond to the eddies around the islands.

(v) Typical flow pattern around a sloped island or a cone reef.

(Photo. 5, Fig. 7). There we see eddies corresponding to the fishing grounds of tunas, skipjack and mackerel, etc.

(vi) Typical flow pattern around a submarine bank.

(Photo. 6, Fig. 8). Similarly we find the fishing grounds of tunas, etc. in the topographical eddies.

(vii) Typical flow pattern around a submarine bar (alike to sea-ridge).

(Fig. 9). In general we can find some fishing grounds near a ridge.

(ix) Typical flow pattern around a oceanic island having insular shelf.

(Photo. 7, Fig. 10). Upwelling was proved by sand pattern and potassium permanganate solution.

(x) Typical flow pattern of a model alike to Tugaru Strait.

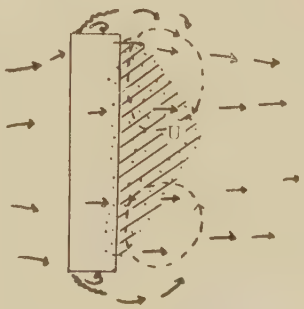


Fig. 9. Schematic chart of current around a rectangular bar. (l:29×h:7.6×b:9 cm.).

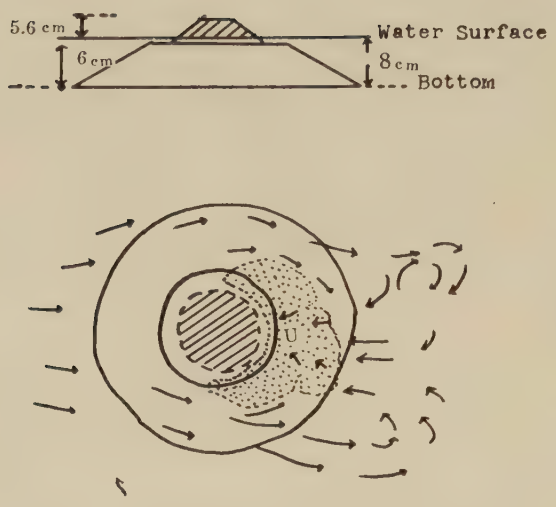


Fig. 10. Schematic chart of currents around a model of oceanic island having insular shelf.
(U: Upwelling zone)

squid fishing grounds coorrespond to those eddies.

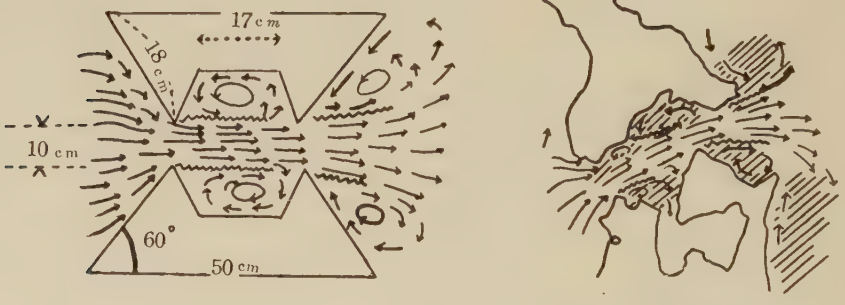
(Photo. 8, Fig. 11).

(x) Typical flow pattern of an island having a bay.

(Photo. 9, Fig. 12). For example pacific mackerel and horse mackerel fishing grounds near Gotō Islands west to Kyūsyū correspond to such eddies in figure.

B. Experiments by means of similar model subjecting to the law of dynamical similitude.

We constructed our models which are made of a concrete block cemented smoothly upon it by a mixture of lime.



a b

Fig. 11. Schematic charts of surface currents and fishing grounds around Tugaru Strait.
(Hatched area shows the squid fishing grounds)

In consideration of the pioneer work of Mr. Mituyo Okada and K. Miyosi (1933)[22] obeying to the law of dynamical similitude, we have chosen the horizontal scale H, the vertical scale Z, taking the velocity of horizontal flow V, time T, length L as $V^2=H=Z\times10^{-6}$, $T^2=L^2/H$ (see Photo. 10).

(i) Typical flow pattern around the model of Idu Islands (Idu-Ōsima～Aogasima) (H: 2×10^{-6}, Z: 1×10^{-4}).

(a) Northerly flow (Photo. 11).

(b) N 30°E. flow. (Photo. 12 Fig. 13).

(c) N 60°E. flow. (Photo. 13).

(d) Easterly flow. (Photo. 14).

Eddies aroused by islands and banks correspond to fishing grounds.

Fig. 12. Schematic chart of surface currents around an island having a bay.

(ii) Typical flow pattern around the model of Idu Island (Mikurazima ~ Idu Ōsima), where H: 6.66×10^{-5} Z: 1×10^{-4}

(a) Northerly flow. (Photo. 15).
(b) N 30°W flow (Photo. 16).
(c) N 30°E flow (Photo. 17).
(d) N 60°E flow (Photo. 18).

Eddies correspond to the fishing grounds of flying-fish, mackerel, etc.

(iii) Typical flow pattern around the above model. (i) Under the influence of wind current. (wind was aroused by electric fan.)

(a) Southerly wind. (Photo. 19).
(b) SW wind. (Photo. 20).
(c) Westerly wind. (Photo. 21).

(iv) Typical flow pattern around the model of Sado Island. (Refer to Fig. 4). (Photo. 22).

Eddies coincide well with the fishing grounds of squid, yellow-tail, etc.

(v) Typical flow pattern in the model of Tateyama Bay. (Photo. 23). (Z: 25×10^{-5})

(a) Easterly flow (Photo. 24).
(b) S 60°E flow (Photo. 25).
(c) S 30°E flow (Photo. 26).
(d) N 60°E flow (—).
(e) S 30°W flow (Photo. 27).
(f) Westerly wind. (Photo. 28).
(g) Northerly wind. (Photo. 29, Fig. 14).

Eddies in the bay and at the head of sea-valley correspond to fishing grounds.

(vi) Typical flow pattern around the model of Tusima Is. (Photo. 30, Fig. 15).

Eddies around the island correspond to the fishing grounds of squid, mackerel and yellow-tail, etc.

Actually we took several oceanographic observations of Kurosio in the adjacent waters of Hatizyō Island and local eddies produced by islands and banks in the area on board of UMITAKAMARU, SHUNKOTSUMARU and SHINYO-MARU (1952–'55)[23]. (See Fig. 3). The fishing grounds of some important commercial fishes (e. g. flying-fish, skipjack and mackerel) appear to locate on such topographically stationary eddy-systems. The successive movement of fishes from such one eddy system to another formed by each island or bank respectively shows apparently the migration of them. T. Tujita (1958)[24] T. Kawakami

(1954)[25], S. Kozima (1955)[26], S. Nagata[26] and others have shown us the favourable mackerel fishing grounds constructed by the eddy-system due to the topographical disturbances.

(3) The combined type of the above (1) and (2), partly topographical and partly dynamical eddy system.

The following examples studied by us are illustrated.

(i) In Japan Sea. (See fig. 16).

The conspicuous meandering front of Tusima Current since the year 1941 to 1955 represents several cyclonic eddies corresponding to the top of the encroaching cold currents which dominate on some configuration (sea valleys, etc.) of deep sea floor and several anticyclonic eddies of warm water mass off the shallow elevation[27]. Those eddies appear rather as the topographically quasistationary but more or less variable.

Fig. 13. Schematic chart of surface currents in the case of N 30°E flow by means of the model shown in Photo. 10. (A: Aogashima, O: Osima)

Along the frontal edge of the Tusima Current the migration route of the pelagic fishes are noted generally. Also, the remarkable boundaries of those several cyclonic eddies coinside with some enrichment patterns (fertilized cold water area due to upwelling) and are important as the fishing ground of sardine, mackerel, etc[27].

(ii) In the East China Sea. (See Fig. 17)

Some complex structure of frontal zone near the shelf edge of the East China Sea at the depths of 50–200 m between the coastl shelf water and the offshore water of Kurosio System.

Commonly the shelf margin is occupied by the relatively turbid water, plenty of plankton, showing higher productivity due to the upwelling of the intermediate slope water mingled with the cascaded water from the bottom layer of the Yellow Sea[27][28][29] (similar to that of Celtic Sea disscussed by L. P. Cooper 1955)[30]

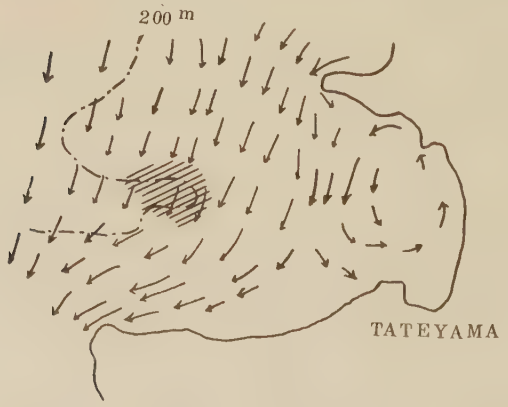


Fig. 14. Schematic chart of northerly wind-drift and fishing ground at the head of sea-valley. (Hatched area shows the mackerel fishing ground)

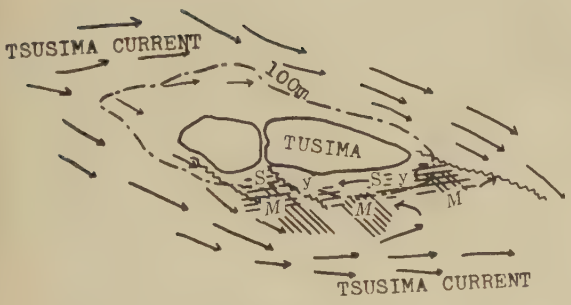


Fig. 15. Schematic chart of surface currents and fishing grounds around Tusima Is.
M: Mackerel fishing ground
s: Squid " "
y: Yellow-tail " "

and moreover the encroaching cold water to the warm Kurosio water at the head of sea valleys on the continental shelf edge are shown, which corresponds to the fishing grounds of horse mackerel, Pacific mackerel and marlins[27)28)].

(iii) Eddies of Subtropical Convergence near Ogasawara Is. (M. Uda 1955)[31)] which correspond to the favourable whaling grounds and tuna fishing grounds (M. Uda, 1937, 1952)[32)33)].

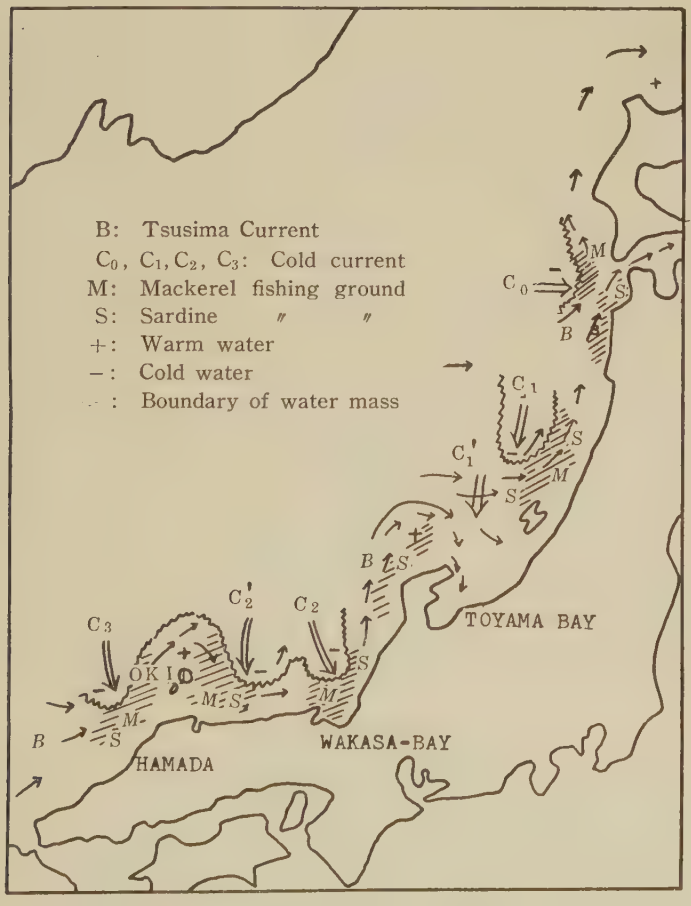


Fig. 16. Currents and water masses in the Japan Sea in relation to fishing grounds.

Fig. 17. Currents and water masses in relation to fishing grounds in the East China Sea. (K: Kurosio, C: cold water mass, M: mackerel fishing ground, M': marlin fishing ground)

(iv) Eddies around the the East Saghaline Cold Current north off Hokkaidō corresponding to the favourable whaling grounds. (M. Uda, 1954)[34].

(v) Eddies on the continental shelves of the South China Sea and East China Sea in relation to the trawl fishing ground. (M. Uda, 1941)[28].

Concluding Remarks.

The present authors emphasize the importance of the enrichment patterns resulting from the eddy systems of the above three kinds in relation to the commercial fishing grounds for their exploitation and conservation. The concentrated areas of food animals including nekton, plankton and benthic fauna are fertilized by upwelling and accumulated or hydrobiologically limited by convergence.

The dynamically-conditioned eddy-systems are subjected to the fluctuation of the currents of water masses.

On the other hand the topographically-conditioned eddy-systems are subjected to the local topographic features including bottom configuration. In general the enrichment of those eddies is affected deeply by the dominant upwelling of the deep water in particular by the cyclonic eddies in the northern hemisphere and by the prevailence of cold current associated with oceanic climate.

The most enriched season seems to occur just in the period succeeding to the convection period or to the turn-over period, and to the turbulent mixing period by current, waves and swell etc. In future, we should study of the hydrobiological mechanism and of the dynamics of edd-system in more detail quantitatively. Coming to the end of this paper we are obliged to state our hearty thanks to the aid of Mr. Keiji Nasu during our model experiments.

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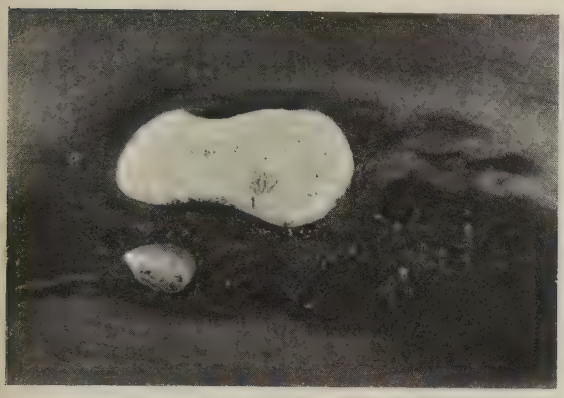

Photo. 1. Model experiment of surface currents around Hatizyō Is. (d. 26 cm) and Kozima Is. (d. 7 cm).
(The direction of major axis of Is. (length:d) runs in parallel to the dir. of current.)
Vel. $V_0=20$ cm/sec , exposure (3.5, 1 sec.)

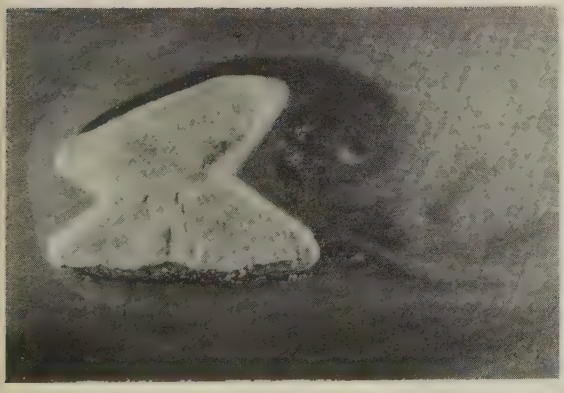

Photo. 2a. Model experiment of surface currents around Sado Is. (d. ca. 30 cm).
(The dir. of major axis of Is. (size d.) runs parallel to the dir. of current.).

Photo. 2b. Model experiment of currents around Sado Is. by means of sand pattern on the bottom.
(The dir. of current ditto.).

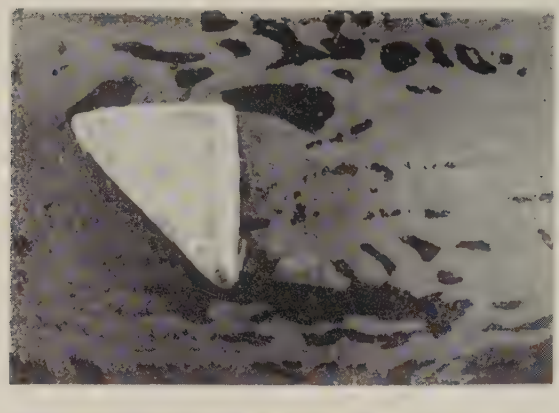

Photo. 3. Expt. of currents around a triangular model by means of sand pattern.
(Oblique size ca 30 cm).

Photo. 4a. Model expt. of surface currents around Idu-Ōsima Is. (d. 15 cm.).

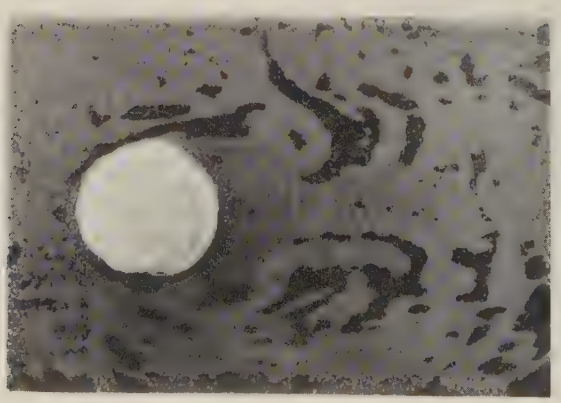

Photo. 4b. Model expt. of currents around Idu-Ōsima Is. by means of sand pattern.

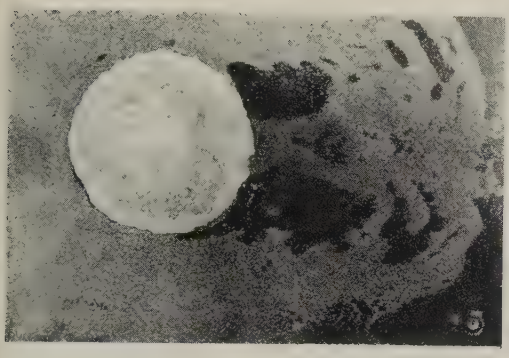

Photo. 5. Model expt. of currents around a sloped island or a cone reef by means of sand pattern.

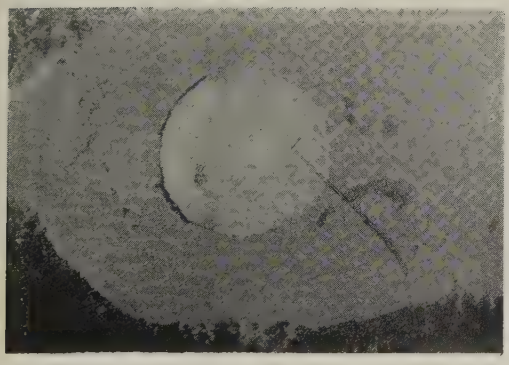

Photo. 6. Model expt. of currents around a submarine bank by means of sand pattern. (V_0=17 cm/s).

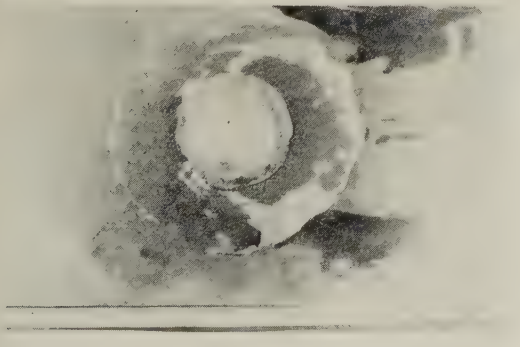

Photo. 7. Model expt. of currents around an oceanic Is. having insular shelf by means of sand pattern.

Photo. 8. Model expt. of surface currents around a strait having bays on both sides.

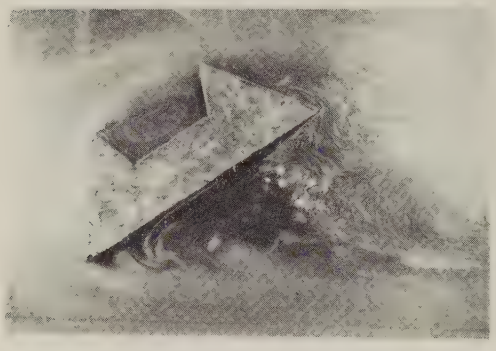

Photo. 9. Model expt. of surface currents around an island having a bay.

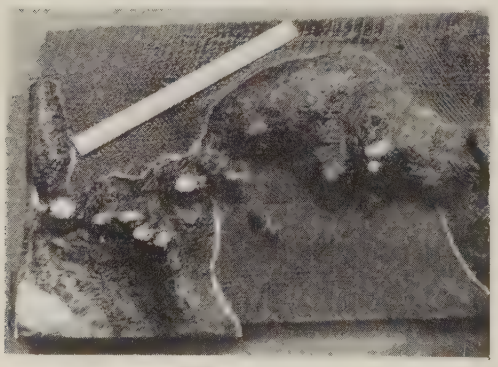

Photo. 10. Our topographical model of Idu Island from 32.2°N to 34.5°N. (model I). (direction of scale in the photo, 145°–325°).

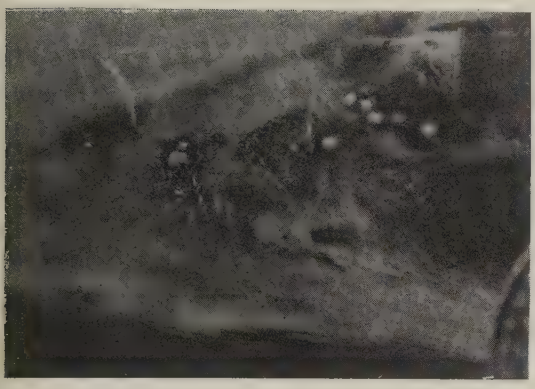

Photo. 11. Model expt. in the case of northerly flow by means of the model I (Photo. 10.).

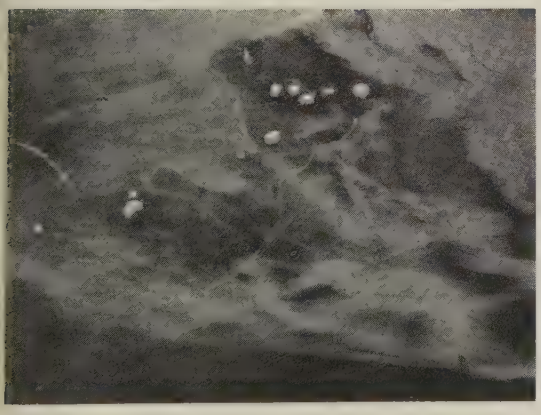

Photo. 12. Model expt. in the case of N 30°E. flow. by means of the model I (Photo. 10.).

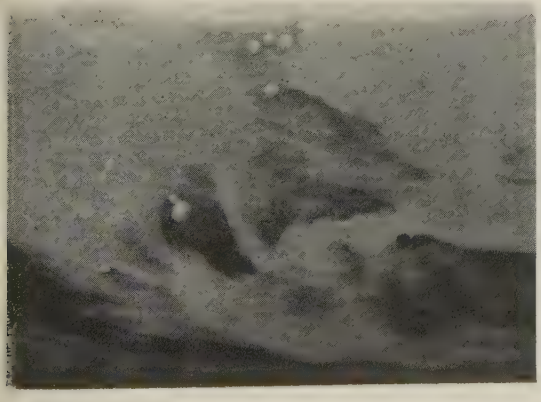

Photo. 13. Model expt. in the case of N 60°E flow by means of the model I (Photo. 10.).

Photo. 14. Model expt. in the case of easterly flow by means of the above model I. (Photo. 10.).

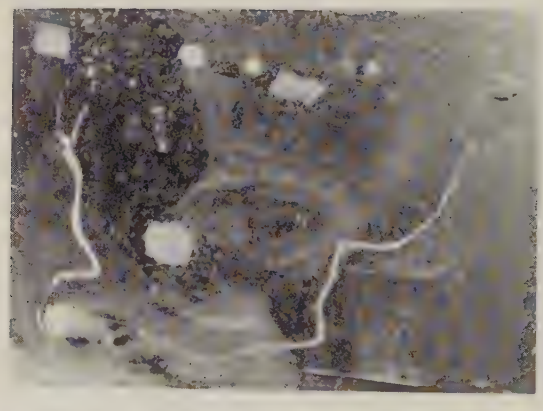

Photo. 15. Model expt. in the case of northerly flow by means of another model II.

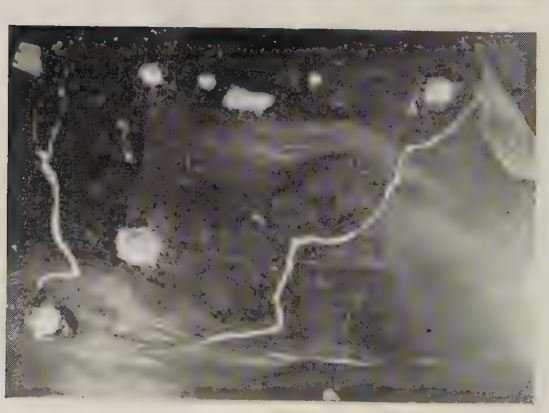

Photo. 16. Model expt. in the case of N 30°W flow by means of another model II.

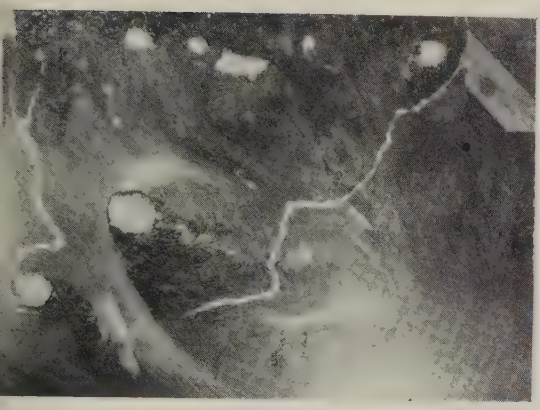

Photo. 17. Model expt. in the case of N 30°E. flow by means of another model II.

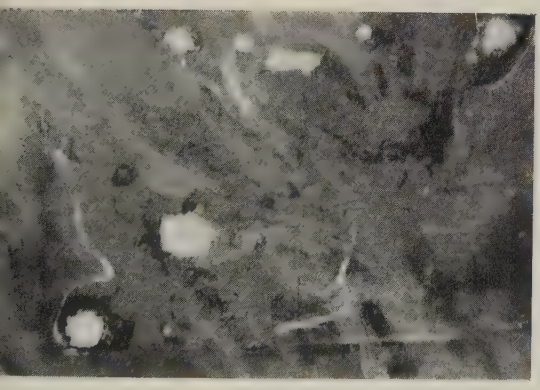

Photo. 18. Model expt. in the case of N 60°E flow by means of another model II.

Photo. 19. Model expt. in the case of wind current under the southerly wind by means of the model I.

Photo. 20. Model expt. in the case of wind-current under SW-wind by means of the model I.

Photo. 21. Model expt. in the case of wind-currents under westerly wind by means of the model I.

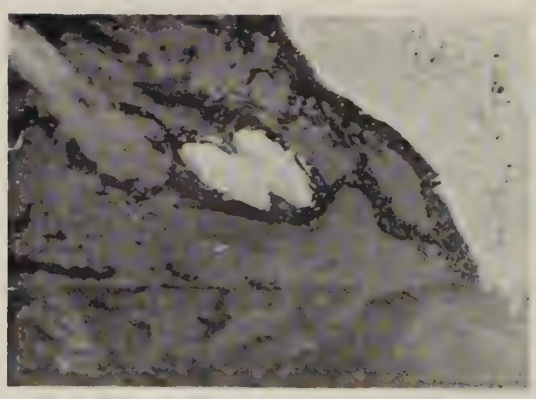

Photo. 22. Model expt. of the currents (surface and bottom) by means of the new model III.

Photo. 23. Topographical model of Tateyama Bay (model IV).
(direction of scale in Photo. 60°–240°).

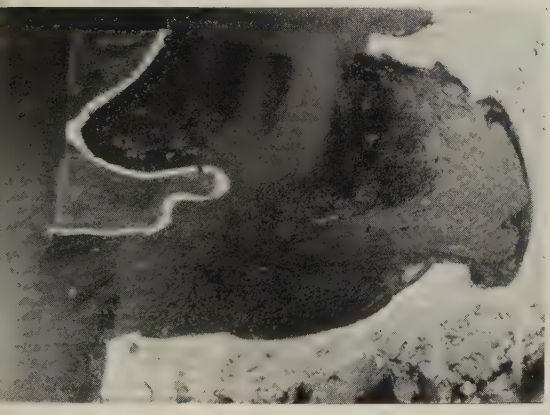

Photo. 24. Model expt. of surface currents in Tateyama Bay in the case of easterly flow by means of the above model IV.

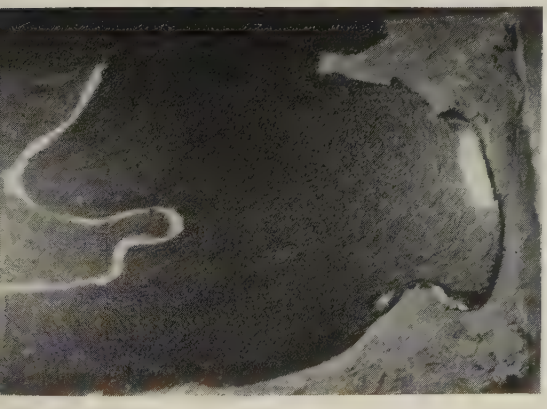

Photo. 25. Model expt. of surface currents in Tateyama Bay in the case of S 60°E flow by means of the above model IV.

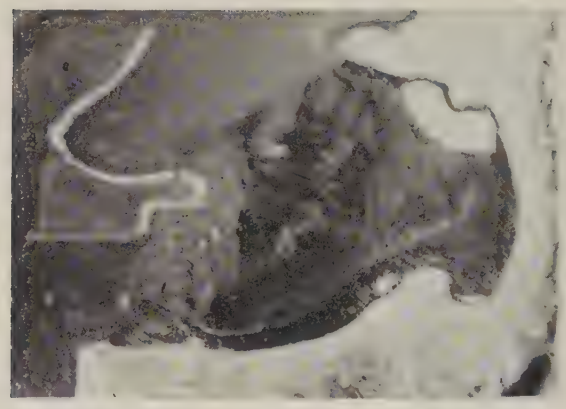

Photo. 26. Model expt. of surface currents in Tateyama Bay in the case of S 30°E flow by means of the above model IV.

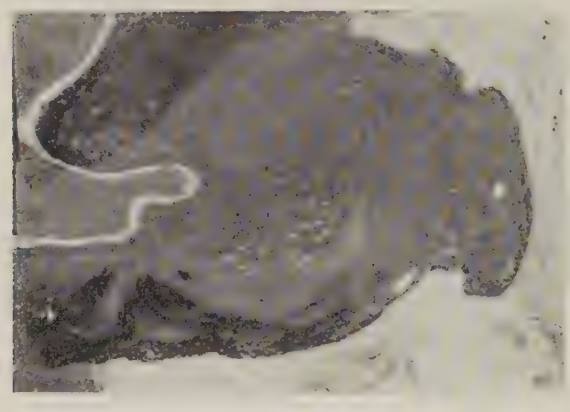

Photo. 27. Model expt. of surface currents in Tateyama Bay in the case of S 30°W flow by means of the above model IV.

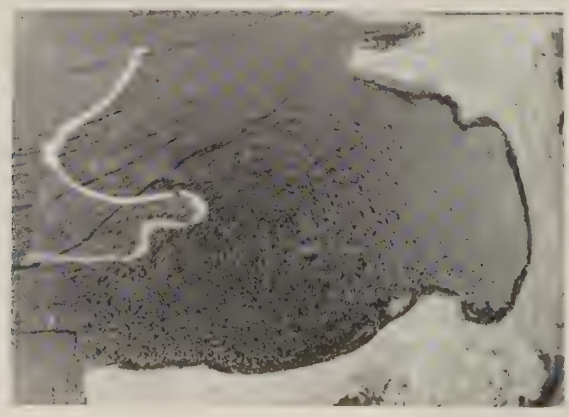

Photo. 28. Model expt. of wind-current in Tateyama Bay under the westerly wind by means of the above model IV.

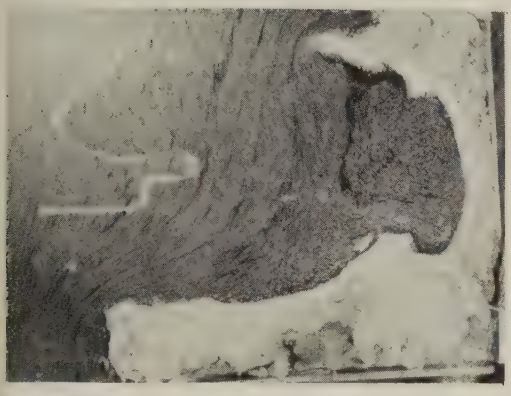

Photo. 29. Model expt. of the wind-currents in Tateyama Bay under northerly wind by means of the above model IV.

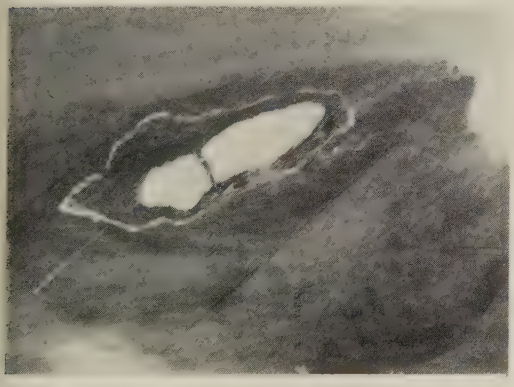

Photo. 30. Model expt. of surface currents around Tusima Is.

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ON THE BOTTOM CHARACTER OF THE SUBMARINE OIL FIELD IN THE CONTINENTAL SHELF OF NORTH EAST HONSYU, JAPAN AND A CONSIDERATION ON THE RELATION BETWEEN SUBMARINE OIL FIELD AND INSULARSHELF OR FISHERIES BANK

Hiroshi Niino

(Received Jan. 15, 1958)

I. Introduction

In the sea of Japan, it is well known that there are many small islands and banks distributed in the offing along the north east Honsyu, Japan. Recently, several new banks were discovered, for example, Yoneyama bank off Sado island, Aoshima bank west off Aoshima, Sensyu bank north off Tobishima island.

The discovery of those banks are very valuable for fisheries and add up a new data on the geological knowledge of submarine oil field. From the view point of geology, the main part of those island and bank belongs to Neogene Tertiary in their basement rocks. The islands and banks are arranged in a zone which run north east to south west direction but the axis of each one tooks somewhat oblique direction.

On the geology of north east Honsyu, Japan, there are a zone of folding in the Tertiary formation along the coast of the Japan Sea and many oil field distributed in this zone. The direction of each oil field and the axis of folding in the oil field took an oblique direction against the general direction of the folding zone. The distintive features of land and sea floor resembles each other and it means that there develope a sort of echelon structure.

The Neogene Tertiary rocks are expose on the continental shelf of this region and oil seapages discovered in many places on the continentalshelf also on the insular shelf. Some of the oil seapage are distributed in the sea floor where situated on the extention direction of the anticlinal axisis of oilfield and the other oil seapage are distributed on a line parallel to such a structure line. The progress of the survey on the fisheries ground gradually explain the geology of the continentalshelf, insularshelf and bank. The knowledge on the oil field advance year by year, the time will come in near feature to develope the submarine oil well in the fisheries ground of the continentalshelf. It is an anxiety how are the influence on the fisheries ground when the submarine oil field develope in the continentalshelf. How is the way to inervene between fisheries and petroleum mining when trubble take place. The detail research on the continentalshelf from the view point of fisheries will give a good suggestion for the solution of this problem.

II. The bottom characters of the new banks and some insularshelf

The bottom samples from Tobishima insularshelf and Kinsyu bank were

dredged by Akita Fisheries Experimental Station Samples from Aoshima insular-shelf, Aoshima bank and Yoneyama bank were dredged by Tokyo University of of Fisheries and several samples from Yoneyama bank were dredged by the Hydrographic Office of Japan. Those sample were used in this study.

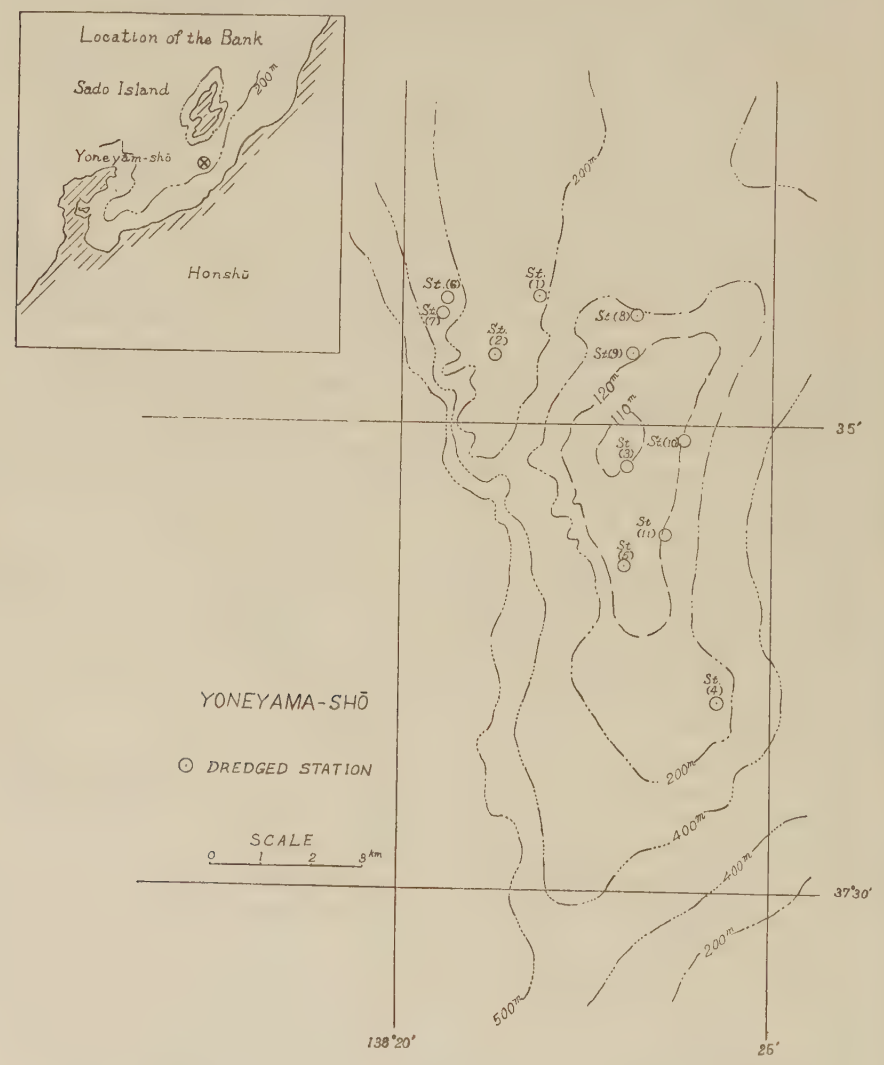

Fig. 1. Submarine topography of Yoneyama Bank and the dredged station.

1. Yoneyama bank

Submarine configuration. Yoneyama bank situated on the midway between Port Ogi, Sado island and Port Kashiwazaki near Mt. Yoneyama, Niigata Prefecture.

Table 1. Dredged position and the bottom characters of Yoneyama Bank
A. Abundant quantity S. Small quantity

	Nnmber of Station	Position		Depth	Bottom character					
					Rock		Gravel		Sand or Mud	Organism
		East longitude	North latitude		Volume	Adhesion of Organism	Volume	Adhesion of Organism		
Dredge by Hydrographic Office	1	138° 21.9′	37° 36.5′	132m	–	–	A	–	S	S
	2	21.2	35.8	161	A	+	–	–	–	S
	3	23.0	34.5	112	–	–	A	–	–	S
	4	24.1	32.0	158	A	+	S	–	–	A
	5	26.0	33.5	121	A	+	–	–	–	–
Dredge by Tokyo University of Fisheries	6	20.6	36.4	240	S	–	–	–	A	A
	7	20.5	36.2	250	A	+	–	–	A	A
	8	23.1	36.2	184	A	+	–	–	A	A
	9	23.0	35.7	163	A	+	S	–	–	A
	10	23.7	34.8	135	–	–	–	–	–	–
	11	23.6	34.6	123	A	+	–	–	S	A

The insularshelf of Sado island extend to south at Ogi and a narrow ridge run to south. The terminal of this ridge elevate to a shallow bank called Yoneyama bank. There lie a deep trough below 400 m. deep between Yoneyama bank and the continental shelf of Honsyu, Japan. The shape of the outline sorrounded by 200 m line is rectangular, 9 km. north to south, 3 km. west to east. The top of the bank is very flat in the depth 120 m.–140 m. and the shallowest point is 106 m. at 37°34′N., 140°06′E. The border of the bank gradually incline to deep sea floor except it east side where steep clif hanging from the edge of the flat top to deep floor.

The bottom character. The bottom samples were obtained from 6 stations by the training ship Shinyomaru of the Tokyo University of Fisheries and 5 stations by Daishikaiyomaru of the Hydrographic Office of Japan.

Rocks were dredged from 4 stations on the bank and 4 stations on the terminal of the ridge close by bank. Each rock fragment is larg, 1 kg. or more in weigh, except the rock fragment dredged from station 6. Organism were attached on the surface of he rock fragment and those rock seems exposed on the sea floor. Gravels were dredged togather with rock, so that some part of the rocky floor seems covered by gravel. The kind of the dredged rocks are:

Station	2	4	5	6	7	8	9	11
Depth m.	161	158	121	240	250	184	163	135
Siliceous shale	*							
Limestone	*							
Sandy shale	*	*	*	*	*		*	
Tuffaceous shale						*		*
Conglomeratic sandsone		*						
Andesite	*							

Sandy shale obtained from station 7 is a fragnent of sandy shale which contain fossil foraminifera and fragment of fossil plant. All rocks dredged from the

bank are sedimentary rock except one andesite block from station 2. The rock character of those sedimentary rocks resemble closely to the rock character of Siiya Formation, Neogene Tertiary of Kashiwazaki oil field.

Gravels were dredged from station 1, 3, 4, 5, 9. The rock character of the gravels are andesite, liparite and sandstone or shale.

Table 2. Organisms dredged from Yoneyama Bank

	Station	1	2	4	5	8	9	11
	Depth (m.)	132	161	158	121	184	163	123
Pelecypoda:	*Chlamys erythrocomata* (Dall)						+	+
	Chlomys irregularis (Sowerby)					+	+	
	Diplodonta orbella (Gould) var.					+		+
	Hiatella orientalis (Yokoyama)					+	+	
	Jouanisiella cumingii (Hanley)					+		
	Lima goliath Smith				+	+	+	+
	Lima zushiensis Yokoyama					+		
	Limopsis tajimae Sowerby					+		
	Ostrea musashiana Yokoyama				+		+	+
	Pseudogrammatodon obliquata Yokoyama						+	
	Venericardia abbreviata (Sowerby)					+		
Gastropoda:	*Emarginula* sp.					+		
	Fusitriton oregonensis (Redfield)						+	
Brachiapoda:	*Craniscus japonicus* (Dall)	+	+	+	+			+
	Laqueus sp.					+	+	+
Coral:	*Dendrophillia albuscula* Van der Horst	+			+		+	
	Amphellia cfr. *ocellata* (Linne)	+	+				+	

2. Insularshelf of Aoshima Island

Aoshima Island situated 20 km. off coast of Iwafune District, Niigata Prefecture. The axis of the island runs northeast to southwest, 7 km. in length, 2 km. in width.

On the geology of this island, the basal complex consist from granite and gabbro. The Neogene Tertiary rocks cover uncoformably on those rocks and basalt intruded into Tertiary rocks.

There are a broad plane in the insularshelf extend northeast direction at the depth 20 m. to 80 m. but the other part is very narrow. Between the east margin of the insularshelf and the sea floor along Iwafune district lie a narrow trough about 80 m. deep.

In August 18th 1952, The training ship Shinyomaru of the Tokyo University of Fisheries dredged at two stations on the north east part of Aoshima insularshelf where called " Tenkotsubami "-familiar name for old fishermen-means bad smell bottom. At the time of survey, many gas bubbles and oil globules comming up to the surface, the dredged positions are:

Station 1. 38 37.3N. 139 19.6E. 96 m. 16 miles from Aoshima

Station 2. 38 33.0N. 139 17.9E. 64 m. 7 miles from Aoshima

The dredged samples from station 1 are rock fragment of gabbro. On the surface of this rock fragment attached *Craniscus japonicus* (Dall).

The dredged samples from station 2 are gray shale block about 1 kg. in

weight and organisms. This gray shale contain fossil fish scales, foraminifera, *sagarites*, and spongespicles. Such a rock character looks like that of the black shale in the Neogene Tertiary formation in the oil field. Species of shells from station 2 are: *Cardita nodulosa* Burguire, *Chlaymys erythrocomata* (Dall), *Diplodonta usta* Gould, *Jouannisiella cumingii* Hanley, *Terebratulla japonica* Sowerby, *Craniscus japonicus* (Dall).

In this survey, only two stations situated on the insularshelf of Aoshima, even such a rough survey, an important data of the submarine oil field were found. Therefore, the detail survey of this area to be desire.

3. Aoshima bank

Aoshima bank situated 13 km. west off Aoshima Island. The area surround by 200 m. bathymetric line is 12 square km., long diameter is 6 km., short diameter is 2 km. The border of the bank incline very steep but the top of the bank is very flat in the depth about 120 m. The shallowest point is 115 m. The author survey this bank at 12 stations by fishing boat and obtained rock fragments from 2 stations.

Station 2 38 34.4N 139 07.7E 132 m. Rock, Gravel, Sand, Organisms
Station 4 38 35.9N 139 09.2E 156 m. Rock, Gravel, Sand, Organisms

The rock character of those samples is calcareous shale contain fossil foraminifera, *Globigerina bulloides* d'Orbigny var. *trilobe* Reuss, *Orbulina universa* d'Orbigny.

Such a kind of rock is very common in the Tertiary formation so called black shale of oil field.

Gravels were dredged together with rock fragment and sand. It seems that a part of rocky floor covered by gravel or sand.

4. Insularshelf to Tobishima Island

Tobishima Island situated 28 km. off the coast of Yamagata Prefecture, 3 km. in length, 1 km. width.

The basement rock is green tuff and plagioliparite, trachy pitchstone, hyperthene andesite, basalt are intruded in green tuff.

The insularshelf at west and east side is narrow but broad at south and north side. There are a broad plane in the insularshelf extend to north east at the depth 120 m. to 180 m. There are a trough about 300 m. deep, 5 km. wide lie between insularshelf and the continentalshelf of Yamagata. This region is a famous good fisheries ground and also it is well known locality of fossil dredged from the sea floor.

In the year of 1946, research ship of the Akita Fisheries Experimental Station dredged a large nodule, 2 kg. in weight, at the station 39°17′N, 139°36′. oE, 100–1300 m. deep.

This nodule is calcareous sandy shale containing many large shells of *Thyasira bisecta* Conrad var *nipponica* Yabe et Nomura.

The preservation of fossils are very good and looks fresh, cuticle layer and liegament existed. Out side of each shell tied by network or hard calcare-

ous sandy shale and each shell arrange in the same direction. Some pebbles contained in the cementing materials. Those pebbles are well waterworn and the rock character are slate, quartzite, trachyandesite. This hard calcareous shell contain fossil foraminifera, *Lubulus* sp., *Globigerina* sp.

Inside of the fossil shell and apature of network were filled by soft muddy sand. Under the microscope, quartz, feldspar, muscobite, biotite, diatom, foraminifera are observed. The species of foraminifera are: *Uvigerina akitaensis* Asano. (very abandant in number of individual), *Cassidulina subglobosa* Brady, Globigerina sp.

The fossil shells in the nodule and dead shell in soft muddy sand are: *Thyasira bisecta* Conrad var. *nipponica* Yabe et Nomura (fossil), *Lunatia pallida* (Broderips et Sowerby) (dead shell), *Nuculana robai* (Kuroda) (fossil), *Acila mirabilis* (Adams et Reeve) (dead shell).

It is a noticeable fact that a characteristic nodule were dredged from Tobishima insularshelf. This nodule contain large shell of *Lucina acutilineata* Conrad which cemented by the network of calcareous sandy shale and the apature of the network filled by soft muddy sand. A small perfect dead shell of *Thyasira bisecta* Conrad var. *nipponica* Yabe et Nomura found in this sand.

Table 3. The station and data of submarine oil seapage

Place	No.	East longitude	North latitude	Depth m.	Bottom character		Oil Seapage		Analysis of gas			
					Rock	Sand or Mud	Oil	gas	CO_2	O_2	CH_4	N_2
off Hirasawa	1	139°56′.20	39°17′.45	7.5	+	+	+	+	0.00	5.0	17.18	27.71
〃	2	〃 38.09	〃 19.38	7.5	−	+		+	0.28	18.91	7.13	74.58
〃	3	〃 39.10	〃 19.45	7.0	+	−	−	+	1.06	3.38	83.28	12.38
〃	4	〃 38.95	〃 19.45	7.5	−	+	+	+	1.58	1.63	85.90	10.83
〃	5	〃 38.86	〃 19.60	9.0	−	+	+	+	3.43	3.28	78.19	14.56
off Nakatakaya	6	140 00.10	〃 21.95	9.0	−	+	−	+				
off Fukasawa	7	〃 01.65	〃 25.75	6.5	+	−	−	+				
〃	8	〃 01.64	〃 25.95	6.5	−	+	+	+	0.37	0.80	88.43	10.40
off Koyagawa	9	〃 01.65	〃 26.90	9.0	−	+	+	+				
off Deto	10	139 58.50	〃 21.50	18.0	+	−	+	+				
〃	11	〃 58.50	〃 22.00	20.0	+	−	+	+				
off Ashikawa	12	140 02.10	〃 28.16	9.0	+	−	+	+	1.35	5.39	71.58	22.18
〃	13	〃 02.10	〃 28.05	9.0	+	−	−	+	0.27	2.97	84.97	7.79
〃	14	〃 02.05	〃 28.05	9.0	−	+	−	+				
off Uchimichikawa	15	〃 03.00	〃 28.35	7.5	−	+	+	+				
off Katsute	16	〃 02.80	〃 33.36	9.0	−	+	+	+	0.00	1.80	84.45	13.75
off Ayukawa	17	〃 03.17	〃 34.65	12.0	−	+	−	+	1.03	5.80	78.17	15.00
off Michikawa	18	〃 02.00	〃 36.53	12.0	+	+	+	+				
off Wakimoto	19	139 55.40	〃 34.20	12.0	+	+	−	+				
off Deto	20	〃 58.46	〃 51.60	23.0	+	−	−	+				
〃	21	〃 58.67	〃 21.63	22.0	+	+	+	+				

In the Wakimoto formation of Akita oil field, there found large size fossil *Thyasira* and *Lucina*. The fossils in the nodules are closely resemble its species also in its size.

5. Sensyu bank

In the year of 1952, The research ship of Akita Fisheries Experimental Station discovered a new bank at the west off Tobishima Island. The shallowest point is at 39°33′0N, 139°33′5E 158 m deep.

The area surrouded by 200 m. bathymetric line is 2 km. from north to south, 1.5 km. east of west. The east border is very steep but the other side icline gradually to deep floor. Two kind of nodules were dredged at 39°33′00N, 33°00′E, 240–260 m. deep.

One nodule is marly sandstone, 5 kg. in weight. The shape of the nodule is disk like

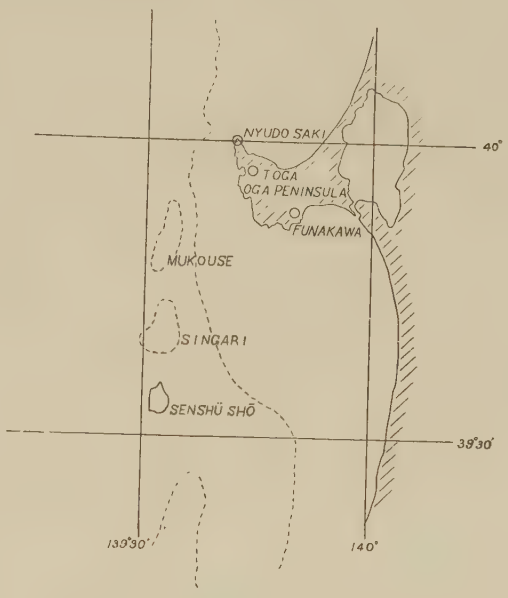

Fig. 2. Position of Sensyu Bank.

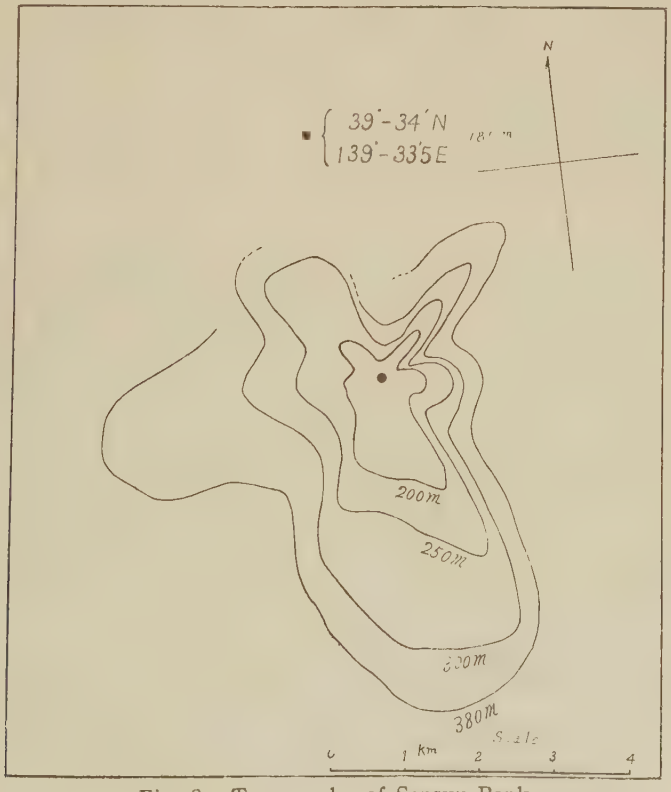

Fig. 3. Topography of Sensyu Bank.

and many holes on the surface. Those holes filled by soft sandy mud. A dead shell of *Thyasira bisecta* Conrad var. *nipponica* Yabe et Nomura found in the sandy mud. On the surface of this nodule attach some kind of bryozoa and hydrozoa.

The other nodule is a concretion of large shells cemented by network of marly sandstone and apature of network filled by soft sandy mud. The weight of this nodule is 5 kg. and organisms attached on the surface. Species of fossil shell and dead shell in the soft sandy mud are:

Colus sp. (new species)	1 specimen	fossil cemented
Neptunea intersculpta (sowerby)	3	fossil cemented
Fulgoraria kaneko Hirase	1	fossil cemented
Cymatosyrinx hotei Otsuka var.	1	fossil cemented
Nuculana robai (Kuroda)	2	fossil cemented
Acila mirabilis (Adams et Reeve)	1	dead shell in sandy mud
Limopsis tajimae Sowerby	2	dead shell in sandy mud
Astarte bennetii Dall	3	dead shell in sandy mud
Thyasira bisecta Conrad var *nipponica* Yabe et Nomura	1	dead shell in sandy mud
Cuspidaria sp. indet.	1	dead shell in sandy mud
Cheliped of crab.	1 fragment	fossil cemented

Species of foraminifera in one gr. of the sandy mud are:

Tricoculina sp.	1
Eliphidium articulatum (d'Orbigny)	2
Uvigerina akitaensis Asano	21
Entosolenia sp.	1
Cassidulina subglobosa Bray	6
Guttulina sp.	4
Globigerina sp.	14

On the species of mollusca, *Astarte benetii* Dall and *Limopsis tajimae* Sowerby are living in the neighbouring sea floor. But the species of the molluscs in the nodule are the same to the species found in Wakimoto sandstone, Neogene Tertiary of oil field. The most superior species in foraminifera is *Uvegerina akitaensis* Asano and this species is also very common in Wakimoto sandstone.

Two nodules dredged from Sensyu bank are closely resemble in their character that of the nodules dredged from insularshelf of Tobishima.

It is a questioanable matter that the consolidated cementing materials and the soft sandy mud in the nodule belongs to the same origin but in general, fauna in the nodules dredged from Tobishima and Sensyu bank are the same type. Therefore it is sure that Neogene Tertiary rocks exposed on the insularshelf of Tobishima and Sensyu bank.

III. The submarine oil field on the continentalshelf of Akita region

The area of the presumptive oil field on the continentalshelf of north east

Honsyu, Japan are: 750 km². at Azikasawa, Aomori Prefecture, 5.100 km². at Akita Prefecture, 6355 km². at Niigata Prefecture. Judging from the data of the geology of banks, deep floor between banks and continentalshelf also belong to the submarine oil field. Most of those area remain without research on the view point of geology. In the year of 1952 the first trial survey on the submarineoil-field of Akita district were done by the direction of the author. The members who jointed in this survey are as follows:

Tokyo University of Fisheries***. Offshore survey; submarine geology
Hiroshi Niino
Takeharu Kumagori
Jiro Ozawa
Yoshio Yamaguchi
Members of Shinyomaru
Akita Fisheries Experimental Station*** Near shore survey
Tan Kato
Masayoshi Nōjo
Osamu Matsumoto
Tokyo Education University*** Gas analysis
Hiroshi Hamaguchi
Nobumitsu Tatsumoto
Niigata University*** Geology of land area
Shozo Nishida
Furukawa Mining Co. Ltd.*** Geology of land area, marine geology
Goro Asano

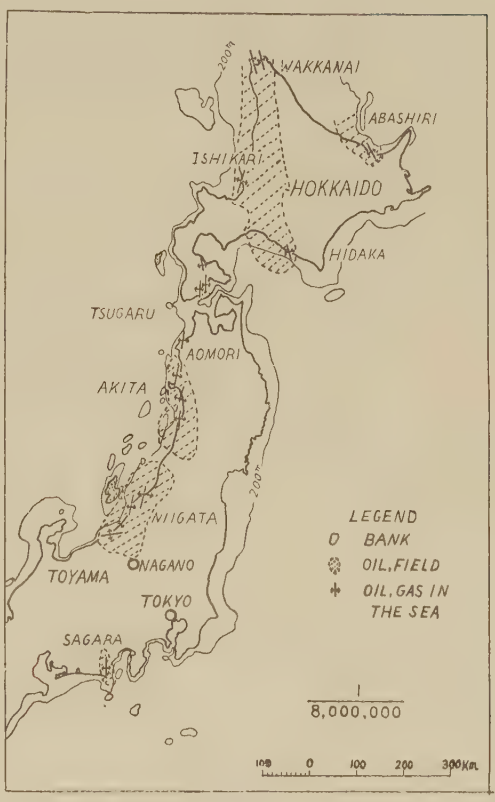

Fig. 4. The distribution of oil field in Japan.

A. Offshore survey.

Examining the record of bathymograph, if find presumptive rocky floor, put Niino's dredge apparate in the sea and when get shock, pul up the dredge aparate. Shinyomaru were used to this purpose.

B. Near Shore survey

Small vessel named Hachiromaru were used in this purpose.

At the time of calm in the sea, the vessel navigate very slowly and if the watchman find gas bubbles or oil globules comming up on the surface, the surveyor adjust the position of vessel by sextant. Then put ancher with bouy in the sea immediately. The detail survey around this position done by dredge or

diving. It need 40 days on the sea for this survey from Funakawa, Oga Peninsula to Hirasawa, near Innai oil field at South Akita Prefecture. Oil seapage found in the sea are at 22 stations by the time of this survey.

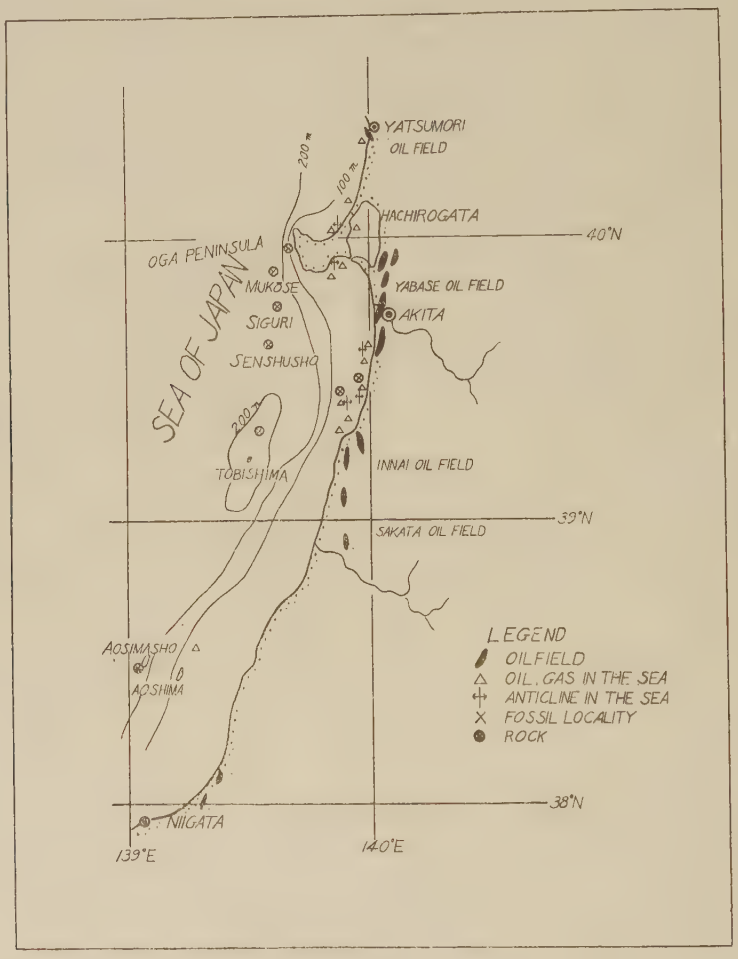

Figure 5. The distribution of oil field at Akita Prefecture and the oil seapage on the continentalshelf.

The survey by diving were done in September 1952 at off Hirasawa where oil seapage were found in the sea. Dr. Robert Dietz of the Naval Electronic Laboratory. U. S. A. gathered bottom samples by aqualung diving and helmet diver gathered gas and bottom samples from the sea floor around oil seapage. the gathered gas were analysed by the member of The Tokyo University of Education.

Hachiromaru, Sensyumaru of The Fisheries Experimental Station of Akita Prefecture and Shinyomaru of The Tokyo University of Fisheries collected bottom samples around oil seapage area by Niino's dredge. The rock, sand and mud ob-

tained from the bottom around oil seapage area were sometimes contain oil globules an distinct oil smell.

The number of the station where oil seapage were found count 24 station. Among 24 stations, gas and oil globule coming up at 15 stations and at 9 stations, gas only.

Fisherman talked that the color of the fish angled at oil seapage area, are somewhat gray or black. It seems some influence on the colour of fish, that, at some oil seapage area, black mud with smell of sulfuretted hydrogen were spread on the bottom.

The most of the oil seapage predominate on the sea bottom shallower than 10 m. deep. One station at N. 39°21′63 E. 139°58′67 22 m is the deepest point in in this region.

C. The data from a submarine trial oil well-sinking

About 1 km. of coast of Michikawa, Yurigun, Akita Prefecture there are many oil seapages arrange along the coast. In the year of 1952, Mr. Subro Iwasa sunk a submarine oil well at 39°34′00N, 140°02′00E, 12 m. deep. The sea floor is sandy bottom. Under the surface of sea floor lie gravel and sand layer of about 3 m. in thickness. This layer is the recent sediment and under this layer lie Tertiary formation. When the well reach at the depth 27 m. under the surface of sea floor, abundant gas gush out and petroleum associated with gas a little. Tertiary rocks in the oil field are not hard. At Akita region, coastal erosion is comparatively strong, so the coast of soft Tertiary rocks retire year by year. This is a reason why rocky floor spread on the sea floor shallower than 10 m. and easy for research of oil seapage. Below 10 m. deep, deposited layer of recent strata add its thickness and the distribution of oil seapage decrease abruptly except rocky floor. If the detail survey on the bottom character were done, it is very convenient for the discovery of submarine oil field.

IV. A consideration on the submarine oil field concerned to fisheries bank, insularshelf and continentalshelf

In the Japan Sea, many small islands and banks arrange in the offing along the north east Honsyu, Japan. Oga Peninsula is once an island and tied by sand bar after Pleistocene.

According to the result of the former research on those banks, the main part of the basement rocks belong to Tertiary formation. The rock character of the bank which situated on the outer margine of the bank zone are lower Neogene Tertiary and young Neogene Tertiary rock prodominate on the banks which situated inside of the banks zone. Upper Neogene Tertiary rock also exposed on the insularshelf and continentalshelf.

Oil seapage in the sea arrange on a line which situated at the extention of anticlinal axis of oil field or pararell to such a structure line. For example, submarine oil seapage at Hirasawa situated on the direction of anticlinal axis, Innai oil field and submarine oil seapage at Michikawa region run paralell to the anticlinal axisis of Michikawa oil field.

Station 21(39°21′63N, 139°58′67E, 22 m.) and station 20 are situated on the

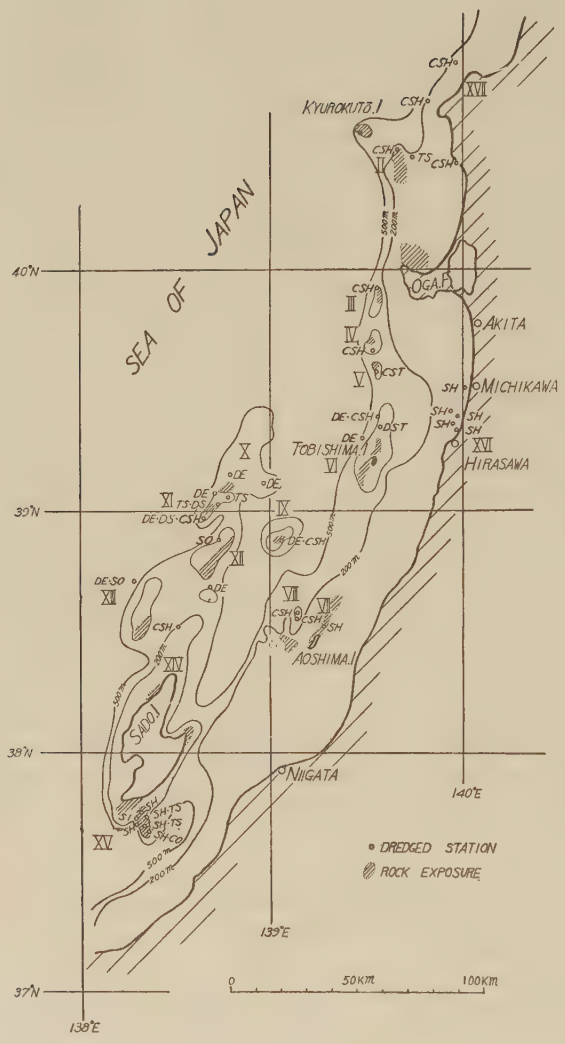

Fig. 6. Distribution of the rock character on the bank and continental-shelf.
C. SH....Calcareous shale,
SH....Sandy shale,
SI....Siliceous shale,
OST....Calcareous sandstone
DE....Diatom earth,
SO....Soft shale,
CS....Calcareous sandstone,
TS....Tufaceous sandstone

I. KYUROKUSHIMA
II. DANSHICHINE BANK
III. SHINGURI BANK
IV. OGAMUKOSE
V. SENSYU BANK
VI. TOBISHIMA, I
VII. AOSHIMA, I
VIII. AOSHIMA BANK
IX. CHOKAISHYO BANK
X. MOGAMI BANK
XI. MUKOSENOOKINOSE BANK
XII. MUKOSE BANK
XIII. HYOTANGURI BANK
XIV. WASHIZAKI BANK
XV. YONEYAMA BANK
XVI. HIRASAWA CONTINENTAL SHELF
XVII. MUTSUIWASAKI

direction of anticlinal axis extend to the sea. Oil globule and gas bubble comming up from the bottom at those stations.

Sandy shale dredged from station 21 contain fossil foraminifera:

Lagena astriata	1
Entoscolenia marginata	1
Entoscolenia multicosta	3
Uvigerina akitaensis	8
Uvegerina subperegrina	1
Angulogerina kokozuraensis	60
Discopulvinulina bradyi	1
Valvulineria sodonica	4

Eponides umbonatus	6
Cassidulina japonica	1
Cassidulina kashiwazakiensis	6
Pullenia apertula	8

Sandy shale dredged from station 20 also contain fossil foraminifera:

Quinqueloculina cfr. *costata*	2
Pseudopolymorphina suboblonga	2
Entosolenia etigoensis	2
Uvigerina akitaensis	60
Uvegerina akitaensis var.	14
Discopulvinulina bradyi	3
Angulogerina kokozuraensis	6
Discopulvinulina	
Epistominella pulchella	10
Epistominella takayanagii (m.s)	2

According to the fossil foraminifera, the rock exposed on those two stations belong to Kitaura formation. Fossil fauna in the rock dredged from station 21 allied to lower part of Kitaura formation and the fossil fauna from station 20 allied to middle and upper part of Kitaura formation of Akita oil field. Station 20 situated 300 m. southwest of station 21. This is a data showing the strata of the submarine oil field incline to west on the extention of anticline axisis, Innai oil field.

From the view point of geology, this facts means that the boundary of the distribution of Neogene Tertiary in the sea floor limited by a line. On this line arrange the banks which situated the most outside position in the bank zone and the geology of the sea floor gradually turn from lower to upper.

The arrangement of island bank and oil seapage on the continentalshelf show a sort of echelon structure. The arrangement of the oil field took the same arrangement. It is a probable case that there develop a folding zone in the Tertiary strata which lie between the line of arrangement out side bank and the land through continentalshelf. In addition to this fact, the scale of the geological structure gradually enlarge from land side to shore side. Therefore, submarine oil field is the most hopefull resource of Japan.

V. Conclusion

Study of the bottom character is very important for fisheries also for submarine geology. Many samples were collected at the time of research on fisheries ground of north east coast Honsyu, Japan.

Petroleum resource is poor on the land area of Japan but fortunately, many data on the hopefull submarine oil field were obtained at the time of research of fisheries ground. The opening of the petroleum well on the continental shelf will give same influence on the fisheries ground. The datail survey on the submarine oil field from the stand point of fisheries is an important problems at present.

VI. Acknowledgment

The author express his sincerely thanks to the members of the submarine oil field research committee and also to Furukawa Mining Co. Ltd. whose foundation used for most part of this research. I am much idebted to Mr. Hiroshi Ozaki and Mr. Saburo Iwasa who determine fossil foraminifera and also Tsuhei Hoshino who give me the samples from Yoneyamatai.

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1
0
3
5
7 cm
2
0
1 cm
3
0
5
7cm

PLATE III.

Fossils dredged from Tobishima Insularshelf. Fig. 1. *Thyasira bisecta* Conrad var. nipponica Yabe et Nomura Fossil separated from nodule. Fig. 2. *Nuculana robai* (Kuroda Fossil in the cementing materials. Fig. 3. Outlook of the nodule. Shells of *Thyasira* arrange in the same direction.

1
2
3
4
5
0 1 cm
0 1 2 cm
0 3 cm
0 1 2 3 cm

PLATE IV.

Fossils dredged from Sensyu bank. Fig. 1. *Fulgoraria kaneko* Hirase Fossil separated from nodule. Fig. 2. Fossil *Fulgoraria kaneko* Hirase in the nodule. Fig. 3. *Nuculana robai* (Kuroda) Fossil from the cementing materials. Fig. 4, A fragment of fossil cheliped from cementing materials. Fig. 5. Fossil *Neptunea intersculpta* (Sowerby) separated from nodule.

1
0
1 cm
2
0
1 cm
3
0
1 cm
4
0
1 cm
5

PLATE VI.

Calcareous concretion and dead shells. from Sensyu bank. Fig. 1 and 2. Young shell of *Thyasira bisecta* Conrad var. *nipponica* Yabe et Nomura. from soft sandy mud. Fig. 3 and 4. *Limopsis tajimae* Sowerby from sandy mud. Fig. 5. *Nuculana robai* (Kuroda) from sandy mud. Fig. 6. Calcareous concretion.